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Recent data for the State of Wisconsin indicates that the National Ambient Air Quality Standards for CO and O_x will not be attained in all areas of the state by 1982, even if all reasonably available control technologies are applied. In view of this, it is likely that the state will request from EPA an extension of the compliance date beyond 1982. In order for this request to be considered, the state must, among other things, have adopted a firm schedule for implementing a motor vehicle inspection and maintenance (I/M) program in the highly urbanized nonattainment areas. In this connection, the State of Wisconsin is currently in the initial states of planning for the implementation of an I/M program. As part of this initial effort, several candidate program configurations have been analyzed from the standpoint of costs, benefits, and other requirements. These analyses, which are reported herein, will provide the basis for the state to select one specific option that will eventually be implemented.

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EVALUATION OF MOTOR VEHICLE EMISSIONS INSPECTION AND MAINTENANCE PROGRAMS IN WISCONSIN
PHASE II

Final Report

by

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ABSTRACT

Recent data for the State of Wisconsin indicates that the National Ambient Air Quality Standards for CO and O_x will not be attained in all areas of the state by 1982, even if all reasonably available control technologies are applied. In view of this, it is likely that the state will request from U.S. EPA an extension of the compliance data beyond 1982. In order for this request to be considered, the state must, among other things, have adopted a firm schedule for implementing a motor vehicle inspection and maintenance (I/M) program in the highly urbanized nonattainment areas. In this connection, the State of Wisconsin is currently in the initial stages of planning for the implementation of an I/M program. As part of this initial effort, several candidate program configurations have been analyzed from the standpoint of costs, benefits, and other requirements. These analyses, which are reported herein, will provide the basis for the state to select one specific option that will eventually be implemented.

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SECTION 1

EXECUTIVE SUMMARY

INTRODUCTION

Need for Inspection and Maintenance Programs

Amendments to the Clean Air Act enacted in 1970 established National Ambient Air Quality Standards (NAAQS) for a number of pollutants including carbon monoxide (CO) and photochemical oxidants (O_x). Further, amendments enacted in 1977 require that the NAAQS for both CO and O_x be attained in all areas no later than 31 December 1982. The U.S. Environmental Protection Agency requires that all states submit revisions to their existing State Implementation Plans (SIP) early in 1979 demonstrating that areas currently violating the NAAQS will be in compliance by 31 December 1982. If it cannot be demonstrated that, even with the application of all reasonably available control technologies, the standards will be obtained, EPA may grant an extension to 31 December 1987 providing that the state meets certain requirements; one such requirement is the establishment of a specific schedule for implementing a motor vehicle inspection and maintenance (I/M) program in urban nonattainment areas with populations greater than 200,000.

Recent ambient air quality data for the State of Wisconsin indicates widespread and frequent violations to both the CO and O_x standards and, further, it is doubtful that all areas in the state can be brought into compliance by 31 December 1982. As a result, it is quite likely that an I/M program will be required in several areas of the state.

What Are Inspection and Maintenance Programs?

Beginning with 1968 model-year vehicles, automobiles manufactured in or imported into the U.S. have had to comply with emission standards specified in the Federal Motor Vehicle Emission Control Program (FMVECP). Under this program, maximum emission rates are established for new vehicles, and manufacturers must demonstrate through an auditing program that their vehicles are in compliance with these emission limits. The emission standards specified by the FMVECP require progressively more stringent control of emissions with each subsequent model year.

To comply with the emission standards, manufacturers have retained their existing engine design concepts, but developed emission control devices (crankcase ventilation control, catalytic converters, etc.) and revised certain system parameter specifications (air-to-fuel ratio, ignition timing, etc.).

This approach to emission control ostensibly satisfied the requirements of the FMVECP for new vehicles. However, surveillance studies conducted by EPA disclosed that the emission rate for these "controlled" vehicles generally increased with time at a much greater rate than was expected, therefore reducing greatly the overall effectiveness of the FMVECP. Further analyses determined that the root causes of the rapid deterioration of these emission control systems could be traced to either improper or inadequate maintenance, or tampering with the devices or system settings.

In light of these findings, effort has been expended on developing techniques for reducing the air quality impact of poor maintenance practices and tampering. One result of this effort is the evolution of the inspection and maintenance concept.

In its most basic sense, inspection and maintenance refers to a program where vehicle exhaust emission levels are measured during specified operating conditions and compared with a specified standard for that particular vehicle configuration. If the measured rate exceeds the standard, the need for some form of maintenance, adjustment or repair is indicated. This is a very simplistic explanation of I/M, but it does serve to define the basic concept involved. A more precise discussion of various technical aspects of I/M may be found in the EPA report, entitled "Summary Report on Vehicle Emissions Inspection and Maintenance Programs."

A variety of approaches have been used to run I/M programs, but the major types are generally in three organizational categories, as follows:

1. Government - Centralized test facilities operated by state, city, or local government (as in New Jersey; Cincinnati, Ohio; Portland, Oregon; and Chicago, Illinois).

2. Contractor - Centralized facilities operated by a private corporation under contract to a government (as in Maricopa and Pima Counties, Arizona).

3. Private Garage - Decentralized facilities operated by private automobile service garages, certified or licensed by government (as in Rhode Island and Nevada).

The major issues that need to be addressed in setting up an I/M program include the following:

1. Type of Emissions Test - Idle or Loaded
2. Geographical Coverage
3. Organizational Approach
4. Frequency of Inspection
5. Enforcement Procedure
6. Vehicles to be Tested
7. Vehicles to be Exempted

8. Data Handling Procedures
9. Adjunctive Programs (e.g., Public Information, Consumer Protection, Mechanic Training, etc.)

BACKGROUND OF THIS STUDY

Given the likelihood of I/M being required in the state, a decision was made to establish an interagency technical committee comprised of staff members from the Departments of Natural Resources and Transportation, whose responsibility would be to develop the initial program framework and provide technical support for state policy makers.

The initial effort by the committee was to review the most current literature relevant to I/M, and investigate a number of specific technical issues that would eventually have to be addressed in the development of the I/M program. From this literature review, a total of 55 possible program scenarios were defined and evaluated. As a result, a final list of six specific program options, which appeared to be the options that were best suited for the state, was defined. These six options were analyzed in detail through a study funded by the Region V Office of the U.S. Environmental Protection Agency, in order to provide a sound basis for selecting one specific program scenario for implementation; this document reports the details of the analysis.

I/M OPTIONS CONSIDERED

As mentioned, a total of six options were analyzed. These are defined in detail in Table 1. Upon reviewing Table 1, it is quite apparent that there are many similarities among the options. The primary differences relate to test type (idle or loaded mode), operation (contractor-run centralized facilities, state-operated centralized facilities, or private garage operation), and whether or not additional types of inspections (i.e., safety and noise) are integrated into the program.

A decision was made to limit the coverage of the I/M program to the nine counties listed below:

Brown County
Dane County
Kenosha County
Milwaukee County
Ozaukee County
Racine County
Walworth County
Washington County
Waukesha County

These counties represent the most highly urbanized areas within the state, and are, therefore, the most appropriate for implementing I/M. Owing to the rural nature of the remaining counties, there would likely not be a significant advantage to extending the program to statewide coverage at the present time.

STUDY RESULTS

The primary objective of this study is to provide a comparative analysis of the six options discussed previously, in terms of benefits, costs, and personnel requirements. Each of these elements is discussed below.

TABLE 1. I/M OPTIONS ANALYZED

Option no.	Geographic coverage	Test mode	Operation and operating agency	Vehicles to be inspected	Remarks
1	Nine counties*	Loaded	Centralized facilities; contractor operated	All passenger cars and light trucks with GVW less than 8,500 pounds except those less than 1 or more than 12 years old	30 percent stringency factor; annual inspections; mechanic training to be performed; safety and noise inspections to be performed, also†
2	Nine counties*	Loaded	Centralized facilities; contractor operated	Same as Option 1	30 percent stringency factor; annual inspections; mechanic training to be performed
3	Nine counties*	Idle	Centralized facilities; contractor operated	Same as Option 1	Same as Option 2
4	Nine counties*	Loaded	Centralized facilities; state operated	Same as Option 1	Same as Option 1 (includes safety and noise inspections)†
5	Nine counties*	Idle	Centralized facilities; state operated	Same as Option 1	Same as Option 2
6	Nine counties*	Idle	Inspections performed in private service stations and garages	Same as Option 1	Same as Option 2

*Includes Brown, Dane, Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties

†Safety and noise inspections would be statewide

Benefits

Emission Reductions--

Again, the two primary benefits that will accrue as a result of an I/M program are reductions in emissions (namely carbon monoxide and hydrocarbon), and fuel savings. The extent of emissions reduction achievable through an I/M program is directly related to a number of factors concerning (1) the nature of the program (i.e., the specific stringency factor used, types of vehicles to be affected, whether or not mechanics are trained specifically in emission-related repair work, etc.), (2) the geographic coverage of the program, (3) nature of the vehicle population affected (i.e., vehicle age and type distributions), and (4) travel characteristics in the affected area (i.e., vehicle miles of travel distribution by vehicle age and type, amount of travel in the area by vehicles registered in other areas, etc.). These features are constant across all six program options being considered here, hence the emission reductions that should occur are the same for each option.

Estimates of emissions reductions for each of the nine counties were developed using travel data provided by the Wisconsin Department of Transportation, and vehicle emission factors and credits (for the I/M program) for EPA's MOBILE 1 model. Included in the computations were hydrocarbon and CO emissions for 1977, 1982, and 1987; emissions for 1982 and 1987 were computed both with and without an I/M program. Table 2 summarizes the emissions from all highway vehicles for 1977 and 1987, and indicates the effect that I/M will have on these emissions in 1987.

It is noted that the U.S. EPA's guidance on I/M program requirements state that by 1987 the (I/M) program must result in a reduction of emissions from affected vehicles, of at least 25 percent. Considering only light-duty vehicles, then, emissions were again computed to establish whether or not the required reduction would be achieved by 1987 using the program factors mentioned previously. A summary of these computations is shown in Table 3. As indicated in Table 3, the computations do not include credit for emissions reductions for light-duty trucks, since these particular credits have not yet been defined by the U.S. EPA. Even without these credits, the emissions reductions expected during 1987 with the I/M program are greater than the required 25 percent. It can be assumed, then, that the options, as defined, meet EPA requirements with regard to minimum standards for emissions reductions. A detailed analysis of emissions reductions by individual vehicle types within each county, is presented in Section 3.

Fuel Savings--

One of the important benefits of I/M programs, in addition to the reduction in vehicular emissions, is potential fuel conservation. A properly tuned engine operates with greater efficiency and therefore consumes less fuel. Reports of improvement in fuel economy differ somewhat from one program to another but most sources agree that a 5 to 10 percent fuel economy improvement for those vehicles undergoing emission-related repair can be expected. One of the purposes of I/M is to provide an incentive to motorists to maintain their cars better than they normally would in the absence of I/M.

TABLE 2. EMISSION REDUCTIONS* (kg/day)

	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M†	1987 I/M‡	Percent reduction 1977-1987 I/M‡	Percent reduction 1987†-1987 I/M‡	1977	1987 without I/M†	1987 I/M‡	Percent reduction 1977-1987 I/M‡	Percent reduction 1987†-1987 I/M‡
Milwaukee - 7 County Metro Area										
Kenosha Co. Freeway & Arterials	9,176	3,500	2,664	71	24	64,663	33,918	23,621	64	30
Milwaukee Co. F&A	70,552	23,031	17,519	75	24	445,290	242,761	175,906	61	28
Ozaukee Co. F&A	5,012	1,916	1,472	71	23	35,460	19,332	13,706	61	29
Racine Co. F&A	12,011	4,226	3,222	73	24	88,172	42,946	30,559	65	29
Walworth Co. F&A	5,910	2,359	1,877	68	20	42,018	25,551	19,485	54	24
Washington Co. F&A	6,622	2,454	1,944	71	21	45,405	25,803	19,455	57	25
Waukesha Co. F&A	21,726	8,150	6,389	71	22	159,339	90,466	68,999	57	24
7 County Local	20,502	6,861	5,264	74	23	175,198	69,895	50,166	71	28
Aggregate	151,571	52,497	40,356	73	23	1,055,545	550,672	401,897	62	27
Brown County										
Aggregate	-	6,170	4,685	-	24	-	61,718	435,461	-	29
Dane County										
Aggregate	-	10,310	7,838	-	24	-	102,948	73,343	-	29

*Does not reflect reductions from light duty trucks

†Reflects only changes in VMT and the effects of the Federal Motor Vehicle Emissions Control Program (FMVECP)

‡Reflects changes in VMT, effects of FMVECP, and the impact of I/M

TABLE 3. LDV AND LDT EMISSIONS REDUCTIONS RESULTING FROM I/M (kg/day)*

County	Carbon monoxide				Hydrocarbons			
	1977	1987 without I/M	1987 with I/M	% reduction for 1987 with I/M with respect to 1987 without I/M	1977	1987 without I/M	1987 with I/M	% reduction for 1987 with I/M with respect to 1987 without I/M
Milwaukee - 7 County Metro Area								
Kenosha Co. Freeway & Arterials	53,951	26,003	15,706	39.6	8,054	3,036	2,200	28.5
Milwaukee Co. F&A	337,928	164,218	97,363	40.8	59,930	18,519	13,007	29.8
Ozaukee Co. F&A	28,146	13,797	8,171	40.8	4,361	1,621	1,177	27.4
Racine Co. F&A	71,282	31,066	18,679	39.9	10,344	3,590	2,586	28.0
Walworth Co. F&A	30,139	16,342	10,276	37.1	4,183	1,923	1,441	25.1
Washington Co. F&A	35,254	17,445	11,097	36.4	5,675	2,042	1,532	25.0
Waukesha Co. F&A	115,888	56,347	34,880	38.1	17,790	6,627	4,866	26.6
7 county locals	135,257	49,289	29,560	40.1	16,124	5,248	3,656	30.0
Total	807,845	374,507	225,732	39.7	127,061	42,606	30,465	28.5
Brown County								
Total	-	48,462	30,290	37.5	-	5,312	3,827	28.0
Dane County								
Total	-	76,111	46,506	38.9	-	8,639	6,167	28.9

---

*This table does not reflect emission reductions for light-duty trucks since the appropriate credits for these vehicles have not yet been defined by U.S. EPA

For this study, a 7 percent increase in fuel economy was assumed for those vehicles undergoing emissions-related repair. Based on this assumption and data regarding vehicle travel in the nine counties, expected fuel economy characteristics for 1987, and relevant program parameters, it is estimated that during 1987 a total of 8.64 million gallons of gasoline would be saved as a result of an I/M program being implemented. Further, if fuel costs $0.70 per gallon in 1987, these motorists would save an estimated $6,050,000, or about $12.76 per vehicle undergoing maintenance.

Costs

The cost computations for Options 1 through 5 are very similar in that the major cost categories are similar in nature for each option. The major cost categories associated with the first five options include (1) capital costs, (2) initial start-up costs, (3) annual operating costs, and (4) annual administrative costs. Again, Options 1 through 5 involve centralized test facilities operated by either a contractor or the state where either emissions, or emissions, safety, and noise testing are conducted. Option 6, however, involves emissions testing at private garages and service stations; therefore the same types of costs as for centralized facilities will not be applicable.

Table 4 presents the annualized costs by major category associated with Options 1 through 4. Several types of comparisons can be made using Table 4. First, and most obvious, the differences in total program costs across these five options are apparent. Options 1 and 4 are the most costly, being approximately twice as expensive as Options 2, 3, and 5. Options 1 and 4, however, include safety and noise inspections therefore requiring more facilities with higher startup and annual operating costs.

It is of interest, too, to compare options that are most similar. Options 1 and 4, for instance, are identical except that the programs are run by a private contractor and by the state, respectively.

The difference in costs between a private contractor-run and state-run options, then, can seem to result primarily from differences in initial start-up costs and annual operating costs. In this example, the state-run program has a higher start-up cost owing to a longer personnel phase-in period (2½ years as opposed to 1½ years). On the other hand, the annual operating costs for the contractor-run options are about 10 percent higher than those for the state-run options owing mainly to taxes levied on the contractor that will not be required of the state. These types of comparisons can also be made between Options 2 and 3, or 3 and 5 to determine the impact on loaded versus idle mode testing, or contractor versus state operated, idle mode inspections, respectively.

Costs associated with Option 6 depend on the level of participation by private facilities; fewer participants mean that each garage will conduct more inspections, therefore a lower breakeven fee will result. The breakeven fee as a function of market participation is shown in Table 5. Also associated with this option is an annual administrative cost to cover adjunctive programs such as surveillance, quality control, public information, etc. This is

TABLE 4. ANNUALIZED COST SUMMARY FOR THE SIX OPTIONS CONSIDERED

Category	Annualized cost for each option*				
	Option 1	Option 2	Option 3	Option 4	Option 5
I. Capital Costs					
1. Land	$ 221,493	$ 78,751	$ 70,459	$ 221,493	$ 70,459
2. Buildings	855,080	303,445	331,198	855,080	268,558
3. Equipment	2,338,734	879,686	667,687	2,338,734	667,687
II. Initial Start-up Costs	826,309	583,920	566,707	946,008	686,416
III. Annual Operating Costs	8,912,152	3,962,268	3,778,983	8,077,452	3,599,688
IV. Annual Administrative Costs	684,810	684,474	684,474	684,810	684,474
Total	$13,838,578	$6,492,814	$6,016,980	$13,123,577	$5,977,282

[*] Assumed interest rate is 6 percent

TABLE 5. OPTION 6 COSTS

Market participation	Private garage breakeven charge
0.20	1.57
0.30	2.36
0.40	3.14
0.50	3.93
0.60	4.72
0.70	5.49
0.80	6.27
0.90	7.06
1.00	7.84

estimated to be $974,543 for a minimum network and $1,327,943 for a network with maximum participation. Cost data is translated to a fee by dividing the total annualized costs found in Table 4 by the average number of yearly inspections; if a free retest is provided, the annualized costs are divided by the average annual registrations, Breakeven fees in constant 1978 dollars are provided in Table 6 for options 1 through 5. The fee for the private garage option is strongly related to the number of individual stations participating in the program. For this type of system, however, the fee is set and the number of stations participating becomes the dependent variable. For this study, an inspection fee of $4.50 was selected, therefore limits could be established on the maximum and minimum number of stations participating. The maximum number occurs where the breakeven fee equals $4.50 (see Table 6); beyond this number, stations would lose money. The minimum number would be limited by the ability of the garages to accommodate the vehicle population to be tested. Based on these limits, the maximum and minimum number of stations required in the nine counties would be 1,130 and 394, respectively.

The fee also must include the state's administrative costs, which are directly related to the number of inspection stations operated. This means that this portion of the fee varies by participation level. For the minimum program participation, this portion of the fee is $0.46; for the maximum participation level, it is $0.59. The total fee in constant 1978 dollars, then, is the sum of the inspection, $4.50, and the administrative fee or from $0.46 to $0.59, for a total of $4.96 to $5.09.

Manpower Requirements

Manpower requirements vary among options reflecting differences in inspection activity and/or administrative requirements. The specific requirements for each option are shown in Table 7, by two categories - administrative personnel and operations personnel.

From Table 7 it can be seen that the administrative personnel requirements are fairly constant across all six options while the operations personnel requirements vary substantially. Administrative personnel would be entirely state employees while the operations personnel would be employed either by the state (in Options 4, 5, and 6) or a contractor (in Options 1, 2, and 3).

Indirect Impacts and Political Issues

In addition to the primary benefits of reducing vehicular emissions and improving air quality, inspection and maintenance programs have indirect impacts. Several aspects of an I/M program may have the potential for becoming political issues and hinder the legislative approval of any particular option. To determine what the potential impacts and issues might be other states' I/M programs were studied and the options themselves were analyzed in detail. The research on these impacts and issues are discussed in detail in Sections 10, 11, and 12, while a brief summary of some of the more salient issues is provided here.

TABLE 6. BREAKEVEN FEES, fc, FOR OPTIONS 1 TO 5[*]

Option	I	II	III	IV	V
Total annualized cost	$13,838,578	$6,492,814	$6,016,980	$13,123,577	$5,977,282
Average annual registrations (1982-87)	1,470,000	1,470,000	1,470,000	1,470,000	1,470,000
Average annual inspections (1982-87)	1,911,000	1,911,000	1,911,000	1,911,000	1,911,000
fc, paid retest	$7.24	$3.40	$3.15	$6.87	$3.13
fc, free retest	$9.41	$4.42	$4.09	$8.93	$4.07

[*] Assumed interest rate is 6 percent. Fees represent constant 1978 dollars in the absence of inflation. These figures are for comparison of options only and do not reflect what the motorist would be charged.

TABLE 7. SUMMARY OF PERSONNEL REQUIREMENTS

Title	Annual salary	Number of positions for each option					
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Administrative							
Administrator	$25,000	1	1	1	1	1	1
Assistant Administrator (Support)	17,000	1	1	1	1	1	1
Assistant Administrator (Operations)	21,000	1	1	1	1	1	1
Legal Council	15,000	1	1	1	1	1	1
Purchasing/Contracts Officer	13,000	2	2	2	2	2	2
Accountant	12,000	1	1	1	1	1	1
Engineer	10,400	1	1	1	1	1	1
Systems Analyst	11,000	1	1	1	1	1	1
Statistician/Programmer	10,500	1	1	1	1	1	1
Mechanic Training Coordinator	13,000	1	1	1	1	1	1
Regional Manager	21,500	3	3	3	3	3	3
Regional Inspector	15,500	6	6	6	6	6	6
Regional Public Information Coordinator	15,500	3	3	3	3	3	3
Mechanic Training Instructor	11,000	1	1	1	1	1	5
Instrument Repair Technician	12,000	1	1	1	1	1	-
Inspector/Licensing Officer	15,500	1	1	1	1	1	6-17
Clerk	7,000	-	-	-	-	-	5
Typist/Secretary	8,000	-	-	-	-	-	10
Operations							
Manager	20,000	20	20	15	20	15	1
Assistant Manager	13,500	20	20	15	20	15	-
Maintenance Persons	12,000	9	7	5	9	5	1
Inspectors	10,400	344	216	141	344	141	2
Total Personnel		419	289	202	419	176	53-64

Indirect Impacts--

There are several indirect impacts that do not relate to specific options but which would result from the implementation of any I/M program. These include the following:

- Health benefits
- Improvement in vehicle performance and vehicle life
- Impact of required maintenance
- Impact on repair and automotive parts industry

The improvement in air quality in those areas where the National Ambient Air Quality Standards are currently exceeded are likely to have some benefits in the health of the affected population. The nature of the benefit would depend, of course, on the severity of air pollution prior to the implementation of the I/M program and the amount of reduction in air pollution resulting from I/M.

Fleet maintenance records indicate that emission inspection and regular maintenance of vehicles improves vehicle performance and decreases overall maintenance costs. There is not yet sufficient data to dimension this benefit although there is currently research underway to establish some quantified relationships.

Studies indicate that average repair costs are in the range of $16 to $32 per failed vehicle. Most repairs consist of carburetor adjustment or a minor tuneup. Repair ceilings, ranging from $50 to $100, or a certain percent of the vehicle's value have been set in many states to mitigate against potential hardships for the small percentage of vehicles that require major repairs.

The mandatory repair of failed vehicles and the increased incentive for vehicle maintenance resulting from I/M programs is likely to produce direct and indirect benefits to the automobile repair and parts industry. There would be an increase in repair work and an increased demand for parts, especially tuneup parts and emission controls. At the beginning of the I/M program, the increased demand for repair work may cause some initial shortages, but with time these should diminish.

Travel to and from the inspection station and waiting time may vary among the options. Generally, the decentralized garage approach requires less travel time. However, there would be more inspection stations spread through the population; this is offset somewhat by the longer waiting time and the possible need to leave the car at the private garage.

Political Issues--

I/M programs, although producing significant benefits to the public such as improvements in air quality, have other potential impacts that the public may perceive as not being particularly desirable and therefore may hinder the overall political acceptance of the program. Such issues or impacts include the following:

- Economic impact on low income citizens;
- Potential overcharging for repairs and performance of unnecessary repair work; and
- Problems of conflict of interest and uniformity of inspection in the private garage approach.

One of the fears expressed about I/M programs has been that it would place a burden on low income citizens by forcing them to make expensive repairs, thereby resulting in rather severe economic hardship. This problem has been significantly ameliorated by instituting repair cost ceilings. Thus, if the cost of the repairs needed to meet the standard exceed the cost ceiling, say of $75 to $100, then the vehicle may receive an inspection waiver. Given the relatively small percentage of vehicles that have been found to need these major repairs, little is sacrificed in terms of air quality benefits by making these exemptions and much is gained in terms of overall public acceptance.

The problem of dealing with repair overcharging or unnecessary repair work can be dealt with in several ways. Some states have instituted formal repair procedures that are specified for various emission failure problems. Mechanics training programs address these problems by encouraging a generally higher level of repair competence and motivation. Quality assurance programs can be designed to identify those garages that charge significantly more than the average repair cost or identify garages generally drawing numerous consumer complaints. Such procedures can be relatively informal or can be tied in with formal licensing of garages or mechanics.

The option with inspection as well as repair in licensed private garages may pose quality assurance and consumer protection problems. With a large number of garages having emission analyzers of varying degrees of quality, and with less uniform supervision, there will probably be less uniformity in the inspection in garages. Moreover, there is an inherent conflict of interest in having the same station conduct both the testing and maintenance phases of I/M.

SECTION 2

INTRODUCTION

BACKGROUND

Amendments to the Clean Air Act that were adopted during 1977 have established that the National Ambient Air Quality Standards (NAAQS) for pollutants such as carbon monoxide (CO) and photochemical oxidants (O_x) must be attained in all areas of the U.S. no later than 31 December 1982. The Amendments also require that each state submit a revised State Implementation Plan (SIP) during January 1979 demonstrating compliance by 31 December 1982. That all states will not be able to demonstrate total compliance by the end of 1982 is recognized in the Amendments and provisions are made for extending the compliance date to 31 December 1987. In order to obtain the extension, however, the revised SIP to be submitted in January 1979 must include (among other things) a specific schedule for the implementation of a motor vehicle emissions inspection and maintenance (I/M) program in those nonattainment areas that have an urbanized population greater than 200,000. Failure to submit an acceptable I/M schedule (or if a reasonable effort toward submitting an acceptable schedule is not being made) will result in rather severe sanctions being imposed on the state.

Preliminary reviews of the status of air quality control regions in the State of Wisconsin have indicated that the NAAQS for O_x and/or CO will not be achieved by 31 December 1982 in all instances. Given the requirements of the Clean Air Act Amendments mentioned above, a decision was made to initiate action that would serve to identify the overall requirements for I/M in the State. This action involved the establishment of an Inter-Agency Task Force, comprised of representatives from the Departments of Natural Resources and Transportation, which will provide a technical advisory function for the State. Also, to assist the State in its early efforts, the Region V Office of the U.S. Environmental Protection Agency contracted a consulting firm - GCA/Technology Division - to provide specific technical assistance to the Inter-Agency Task Force.

The initial effort in this connection was the development of background data regarding the general technical and administrative aspects of I/M programs, and a summary of various states' experiences to date with actual program operation. GCA provided this background information through a series of technical memoranda and a summary report.

Based in part on the data provided by GCA, the inter-Agency Task Force identified and evaluated a series of 55 possible I/M program options. As a result of the evaluation, the Task Force selected a total of six specific I/M program scenarios that appeared to be the most desirable for implementation. The six program options were then transmitted to GCA for detailed analysis and evaluation under a continuing contractual agreement with EPA. The intent was to provide a comparative analysis of the options in terms of costs, benefits, degree of difficulty regarding implementation, etc., that the Task Force could utilize as a primary reference in selecting the one particular option that will eventually be implemented. The purpose of this document is to present the details and conclusions of the analysis.

What are Inspection and Maintenance Programs?

Prior to discussing specific details regarding inspection and maintenance (I/M) program issues in Wisconsin, a general discussion of the basic concepts of I/M are in order.

Beginning with 1968 model-year vehicles, automobiles manufactured in or imported into the U.S. have had to comply with emission standards specified in the Federal Motor Vehicle Emission Control Program (FMVECP). Under this program, maximum emission rates are established for new vehicles, and manufacturers must demonstrate through an auditing program that their vehicles are in compliance with these emission limits. The emission standards specified by the FMVECP require progressively more stringent control of emissions with each subsequent model year.

To comply with the emission standards, manufacturers have retained their existing engine design concepts, but developed emission control devices (crankcase ventilation control, catalytic converters, etc.) and revised certain system parameter specifications (air-to-fuel ratio, ignition timing, etc.). This approach to emission control ostensibly satisfied the requirements of the FMVECP for new vehicles. However, surveillance studies conducted by EPA disclosed that the emission rate for these "controlled" vehicles generally increased with time at a much greater rate than was expected, therefore reducing greatly the overall effectiveness of the FMVECP. Further analyses determined that the root causes of the rapid deterioration of these emission control systems could be traced to either improper or inadequate maintenance, or tampering with the devices or system settings.

In light of these findings, effort has been expended on developing techniques for reducing the air quality impact of poor maintenance practices and tampering. One result of this effort is the evolution of the inspection and maintenance concept.

In its most basic sense, inspection and maintenance refers to a program where vehicle exhaust emission levels are measured during specified operating conditions and compared with a specified standard for that particular vehicle configuration. If the measured rate exceeds the standard, the need for some form of maintenance, adjustment or repair is indicated. This is a very simplistic explanation of I/M, but it does serve to define the basic concept involved. A more precise discussion of various technical aspects of I/M may be found in the EPA report entitled "Summary Report on Vehicle Emissions Inspection and Maintenance Programs."

A variety of approaches have been used to run I/M programs, but the major types are generally in three organizational categories as follows:

1. Government - Centralized test facilities operated by state, city, or local government (as in New Jersey; Cincinnati, Ohio; Portland, Oregon; and Chicago, Illinois).
2. Contractor - Centralized facilities operated by a private corporation under contract to a government (as in Maricopa and Pima Counties, Arizona).
3. Private Garage - Decentralized facilities operated by private automobile service garages, certified or licensed by a government (as in Rhode Island and Nevada).

The major issues that need to be addressed in setting up an I/M program include the following:

1. Type of Emissions Test - Idle or Loaded
2. Geographical Coverage
3. Organizational Approach
4. Frequency of Inspection
5. Enforcement Procedure
6. Vehicles to be Tested
7. Vehicles to be Exempted
8. Data Handling Procedures
9. Adjunctive Programs (e.g., Public Information, Consumer Protection, Mechanic Training, etc.)

PROGRAMS OPTIONS CONSIDERED

As indicated above, the State Inter-Agency Task Force has selected six specific I/M program scenarios for consideration here. Included are (1) centralized, contractor-operated, steady-state loaded mode emission testing, combined with noise and safety inspections; (2) centralized, contractor-operated, steady-state, loaded mode emission testing; (3) centralized, contractor-operated, idle mode emission testing; (4) centralized, state-operated, steady-state, loaded mode emission testing, combined with safety and noise testing; (5) centralized, state-operated, idle mode emission testing; and (6) decentralized, private garage/service station operation using idle mode emission testing, with provisions for a referee station. The primary features of each option are listed in Table 8.

The programs must be defined further in several respects. First, it is intended that only nine counties be affected by I/M, including:

TABLE 8. I/M OPTIONS ANALYZED

Option no.	Geographic coverage	Test mode	Operation and operating agency	Vehicles to be inspected	Remarks
1	Nine counties*	Loaded	Centralized facilities; contractor operated	All passenger cars and light trucks with GVW less than 8,500 pounds except those less than 1 or more than 12 years old	30 percent stringency factor; annual inspections; mechanic training to be performed; safety and noise inspections to be performed, also†
2	Nine counties*	Loaded	Centralized facilities; contractor operated	Same as Option 1	30 percent stringency factor; annual inspections; mechanic training to be performed
3	Nine counties*	Idle	Centralized facilities; contractor operated	Same as Option 1	Same as Option 2
4	Nine counties*	Loaded	Centralized facilities; state operated	Same as Option 1	Same as Option 1 (includes safety and noise inspections)†
5	Nine counties*	Idle	Centralized facilities; state operated	Same as Option 1	Same as Option 2
6	Nine counties*	Idle	Inspections performed in private service stations and garages	Same as Option 1	Same as Option 2

*Includes Brown, Dane, Kenosha, Milwaukee, Ozaukee, Racine, Walworth, Washington, and Waukesha Counties

†Safety and noise inspections would be statewide

1. Brown County
2. Dane County
3. Kenosha County
4. Milwaukee County
5. Ozaukee County
6. Racine County
7. Walworth County
8. Washington County
9. Waukesha County

These counties are shown in Figure 1. The Task Force indicated that the noise and safety inspection aspects shall be considered for statewide implementation.

Secondly, several additional aspects of the candidate programs were defined concerning parameters such as cut points, vehicle exemptions, inspector training, etc. Specifically, these are:

- Inspection Frequency - Annual inspections will be performed and a staggered schedule will be established so that approximately 11 percent (accounting for reinspections of failed vehicles) of the affected vehicle population will be inspected each month.

- Vehicle Categories to be Inspected - Vehicles to be included in the mandatory I/M program include: (a) all light-duty, gasoline-powered vehicles other than those that are less than 1 year old (based on model year) or more than 12 years old; and (b) all light-duty, gasoline-powered trucks with a gross vehicle weight (GVW) of 8,500 pounds or less.

- Stringency Factor - This parameter has been defined as 30 percent.

- Test Types - The safety and noise inspection programs will be entirely new. It is intended that the safety program provide detailed, diagnostic inspections utilizing both dynamic and static test modes, as well as visual and manual inspections.

  The noise program is envisioned as focusing on ensuring that adequate exhaust system components are used on all vehicles, therefore, the pass/fail criterion would simply be a standard specifying the maximum exhaust noise level permitted under some operating mode specification (e.g., idle, idle at a specific engine speed, etc.).

- Inspector and Mechanic Training - Regardless of the program option selected, a basic requirement would be that individuals performing either inspections or performing maintenance would be required to participate in a training program.

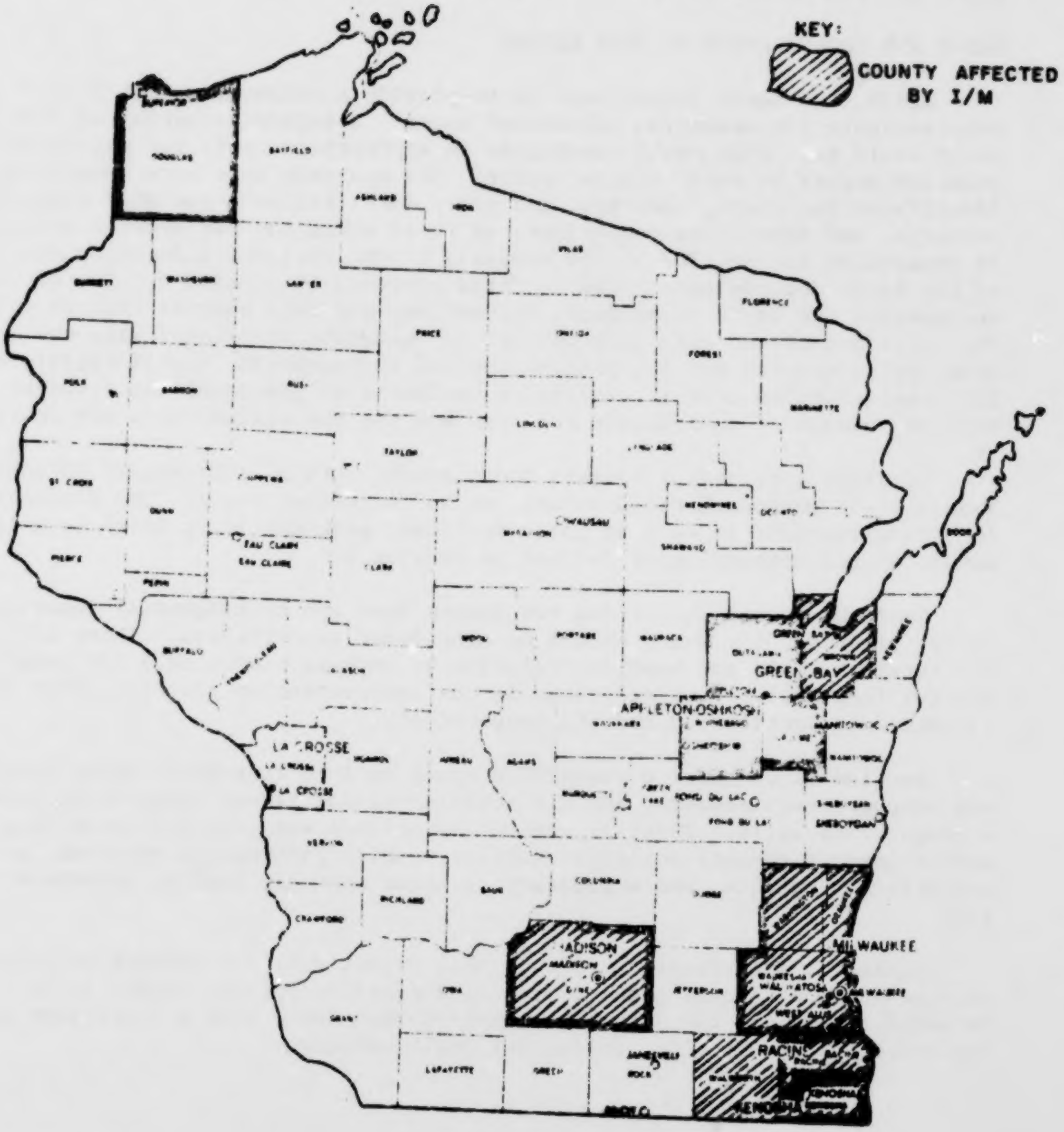
KEY:
COUNTY AFFECTED BY I/M
GREEN BAY
APPLETON-OSHKOSH
LA CROSSE
MADISON
MILWAUKEE
RACINE
KENOSHA

Figure 1. Wisconsin counties affected by I/M.

The inspection frequency, vehicle category, stringency, and inspector/mechanic training parameters described above will be identical for all six basic options; the safety and noise inspection program specifications will be identical for two options where these elements are to be considered.

BASIS AND ORGANIZATION OF THIS REPORT

Again, the basic intent here is to provide a comparative analysis of the six-candidate I/M scenarios delineated above. A logical question at this point would be: What would constitute an appropriate basis for gaging the relative merits of each program option? The approach used here focuses on identifying the costs, benefits, and other implications associated with each scenario, and developing comparisons of these among the six program options. In presenting the results of the analysis of the options, a detailed discussion of the basic methodologies used is first provided in Section 3. The discussion encompasses (1) basic techniques, assumptions and data sources used to define the costs associated with each option; (2) benefits associated with the I/M programs in general and the program applied in Wisconsin, specifically; and (3) considerations used in developing estimates of personnel requirements - both the number of individuals required and the associated costs are described.

Sections 4 through 9 discuss the specific options with regard to costs, benefits and personnel requirements, on an individual basis. The discussion is option-specific in each of these sections, although it is based to a large extent on the methodologies defined in Section 3.

Sections 10 and 11 discuss two issues that are of tangential importance in I/M planning, but which should be considered nevertheless. These include (1) external costs and benefits relative to implementation of a I/M program, and (2) legislative considerations in the implementation process, which are discussed in Sections 10 and 11, respectively.

Section 12 provides a comparison among options regarding costs, benefits, and manpower requirements, and a discussion of additional features of each on a comparative basis. Finally, several Appendices are provided describing method used to compute emission benefits, public information programs, a sensitivity analysis, and a glossary of terms commonly used in reference to I/M.

Again, it is stressed here that this report does not attempt to provide recommendations regarding the choice of a specific option; rather it is intended to provide the State Inter-Agency Task Force with a sufficient basis for selecting one specific option for implementation.

SECTION 3

METHODOLOGIES

INTRODUCTION

As previously indicated, this section is intended to provide a comparative analysis of the primary factors associated with the six options. Specifically, the primary factors that will serve as the basis for developing the comparisons include benefits, costs, and manpower requirements associated with the various options. It is noted that there are several elements in all the factors that are common to all options; these will be indicated in the discussion.

BENEFITS

The primary benefits associated with an I/M program are, first, reductions in hydrocarbon and carbon monoxide emissions, and second, improvements in the fuel efficiency of vehicles undergoing related maintenance. The expected level of benefits (that is, the amount of emission reduction and fuel savings) is constant across all six I/M options being considered here. The following provides both a description of the methods used to quantify these benefits and the results of the analysis. It is noted that other benefits (both positive and negative) may accrue also, however, these are considered to be secondary and will be discussed in a subsequent section as external factors.

Emissions Reductions

To assess the reductions from the I/M program being considered here, county emission inventories for 1977 and 1987 without I/M, and 1987 with I/M, were prepared.* Comparison of the two inventories without I/M indicates the general trend in vehicular emissions, taking into account both increases (usually) in travel and a general decrease in the average vehicle emission rate with time resulting from the increased stringency of the Federal Motor Vehicle Emission Control Program. The actual effectiveness of the I/M program is seen by comparing the two inventories reflecting 1987 emissions.

The emission inventories were developed using EPA's Mobile I computer routine. Input data regarding vehicle-miles of travel by vehicle type and roadway category, travel speeds, etc., were provided for each county by the Wisconsin Department of Transportation. As indicated previously, an assumed stringency factor of 30 percent and specification of mandatory I/M applying only to light-duty, gasoline-powered cars and trucks between 1 and 13 years old were used (a detailed description of the development of these inventories is provided in Appendix A). It is assumed, further, that the program is fully implemented by the end of 1982. It is noted that the emission reductions are identical for all options being evaluated here, therefore only one set of data are presented.

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* 1977 emissions data were not prepared for Dane and Brown Counties owing to the lack of required data.

Emissions are reported in two forms; first as an emission rate (in grams per mile) in Tables 9 and 10, and secondly, as total daily emissions in Tables 11 and 12. As can be seen, the I/M program should, by 1987, result in reductions in hydrocarbon and carbon monoxide emissions in the individual counties ranging from 20 to 24 percent and 24 to 30 percent, respectively, beyond those reductions expected from the FMVECP. Again, these reductions reflect the impact of any one of the six options under consideration.

Fuel Savings

There are no firm figures to date regarding the effect of an I/M program on fuel economy. It is generally accepted that the inspection sequence has a favorable influence on fuel economy by providing the incentive for owners to maintain their vehicles at higher standards than they would in the absence of I/M.

Estimates of fuel savings vary from a 4 percent improvement, noted in California's Riverside Trial Program (idle mode), to a 10 percent savings, based on the first 6 months that Hamilton Test Systems operated a program for Arizona. These figures are for light-duty vehicles that failed the emissions test and have thus been repaired. Noting such studies as these, EPA has suggested a range of 5 to 10 percent for expected fuel savings on repaired vehicles. A 7 percent figure is used here as an average for calculations. This figure may be revised if the results from an ongoing study in Oregon prove more conclusive.

These fuel economy figures must be qualified somewhat in order to be meaningful. If the 4 percent improvement figure noted in California is "deteriorated" over 1 year and distributed equally over the total vehicle population tested, fuel economy improvement is only 0.6 percent. Over time, the fuel economy realized by I/M will decline. This is particularly true for that segment of the vehicle population that upgraded maintenance levels to meet I/M standards.

There are also other important variables to be considered that influence fuel economy figures, and perhaps can be pointed to as the reasons for so many different study results thus far. These include test mode, characteristics of the pertinent vehicle population, geographic coverage of the program and stringency rate used as well as the amount of time the program has been in effect.

TABLE 9. SUMMARY OF HYDROCARBON EMISSIONS PER VMT (gm/VMT)

County	Heavy-duty trucks				Light-duty vehicles						Travel-weighted average				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 auto	1987 without I/M auto	1987 I/M auto	1977 LD-truck	1987 without I/M LD-truck	1987 I/M LD-truck[a]	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M	Percent reduction 1987-1987 I/M
Milwaukee - Seven County-Metropolitan Area															
Kenosha County, freeway and arterials	2.59	1.51	15.40	5.22	5.12	1.30	0.95	7.06	2.72	2.72	5.65	1.59	1.21	78	24
Milwaukee County, freeway and arterials	2.64	1.78	17.85	6.93	5.76	1.63	1.08	7.63	3.15	3.15	6.44	2.60	1.52	76	24
Ozaukee County, freeway and arterials	2.57	1.41	13.49	4.62	4.81	1.31	0.90	5.73	2.53	2.53	5.07	1.50	1.15	77	23
Racine County, freeway and arterials	2.52	1.47	16.24	5.39	5.31	1.42	0.96	7.31	2.82	2.82	5.83	1.66	1.26	78	24
Walworth County, freeway and arterials	2.66	1.53	13.08	4.82	4.83	1.27	0.81	6.51	2.16	2.16	5.42	1.54	1.23	77	20
Washington County, freeway and arterials	2.57	1.50	12.79	4.43	4.73	1.31	0.90	6.43	2.55	2.55	5.20	1.57	1.26	76	20
Waukesha County, freeway and arterials	2.59	1.54	13.87	4.65	4.96	1.36	0.91	5.96	2.63	2.63	5.59	1.65	1.29	77	22
Seven-County local	4.42	3.36	28.76	12.76	7.17	2.22	1.43	9.43	4.22	4.22	8.45	2.88	2.21	74	23
Aggregate	2.83	1.39	19.39	7.25	5.36	1.54	1.03	7.10	2.91	2.94	6.22	1.88	1.44	77	23
Brown County															
Aggregate	-	2.46	-	8.05	-	1.77	1.17	-	3.10	3.10	-	2.12	1.61	-	24
Dane County															
Aggregate	-	2.12	-	5.34	-	1.58	1.05	-	2.81	2.81	-	1.89	1.44	-	24

[a] No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

TABLE 10. SUMMARY OF CARBON MONOXIDE EMISSIONS PER VMT (gm/VMT)

County	Heavy-duty trucks				Light-Duty vehicles						Travel-weighted average				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 auto	1987 without I/M auto	1987 I/M auto	1977 LD-truck	1987 without I/M LD-truck	1987 I/M LD-truck*	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M	Percent reduction 1987-1987 I/M
lwaukee - Seven-County tropolitan Area															
Kenosha County, freeway and arterials	15.71	11.30	161.95	114.69	34.61	11.73	6.24	41.88	25.42	25.42	38.41	15.45	10.76	72	30
Milwaukee County, freeway and arterials	25.07	13.21	182.86	125.93	32.06	14.21	7.57	49.98	30.82	30.82	42.63	21.03	15.24	62	28
Ozaukee County, freeway and arterials	15.30	10.52	156.02	111.84	31.05	11.01	5.85	36.60	23.34	23.34	35.46	15.13	10.73	70	29
Racine County, freeway and arterials	13.45	10.97	174.61	116.61	36.93	12.07	6.42	40.12	26.53	26.53	42.76	16.84	11.99	72	29
Walworth County, freeway and arterials	15.21	11.25	148.87	107.87	30.93	10.61	5.64	37.01	22.73	22.73	38.52	16.71	12.74	67	24
Washington County, freeway and arterials	14.96	11.16	147.47	110.05	29.82	10.[illegible]4	5.81	23.47	23.50		35.67	16.89	12.58	65	25
Waukesha County, freeway and arterials	15.29	11.46	157.68	119.96	32.24	11.29	6.01	39.38	23.37	23.37	40.98	18.26	13.92	66	24
Seven-County local	30.28	27.18	268.72	164.22	60.75	20.28	10.85	71.06	43.63	43.63	72.20	29.33	21.05	71	28
Aggregate	16.99	11.89	180.90	129.17	35.28	13.35	7.11	47.82	27.92	28.18	43.29	19.68	14.36	67	27
rown County															
Aggregate	-	18.89	-	133.36	-	15.72	8.38	-	31.81	31.81	-	21.19	14.95	-	29
me County															
Aggregate	-	15.88	-	121.78	-	13.65	7.26	-	27.86	27.86	-	18.89	13.45	-	29

o reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be stablished by EPA. Appropriate adjustments will be made when the credits are made available.

TABLE 11. SUMMARY OF DAILY HYDROCARBON EMISSIONS (kg/day)

	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 LD-truck	1987 without I/M LD-truck	1987 I/M LD-truck*	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M	Percent reduction 1987-1987 I/M
Milwaukee - Seven-County Metropolitan Area																				
Kenosha County, freeway and arterials	244	157	878	307	1,122	464	7,312	2,607	1,772	742	428	428	8,054	3,036	2,200	9,176	3,500	2,664	71	24
Milwaukee County, freeway and arterials	411	323	10,251	4,189	10,662	4,512	55,665	16,363	10,851	4,265	2,156	2,156	59,930	18,519	13,007	70,592	23,031	17,519	75	24
Ozaukee County, freeway and arterials	162	96	549	199	711	295	4,036	1,426	982	325	195	195	4,361	1,621	1,177	5,072	1,916	1,472	71	23
Racine County, freeway and arterials	191	133	1,476	503	1,667	636	9,322	3,102	2,098	1,022	488	488	10,344	3,590	2,586	12,011	4,226	3,222	73	24
Walworth County, freeway and arterials	168	128	959	308	1,127	436	4,095	1,549	1,067	688	374	374	4,783	1,923	1,441	5,910	2,359	1,877	68	20
Washington County, freeway and arterials	135	108	812	304	947	412	4,920	1,620	1,110	755	422	422	5,675	2,042	1,532	6,622	2,454	1,944	71	21
Waukesha County, freeway and arterials	239	152	3,697	1,371	3,936	1,523	16,052	5,557	3,796	1,738	1,070	1,070	17,790	6,627	4,866	21,726	8,150	6,389	71	22
Seven-County local	386	32	3,992	1,581	4,378	1,613	14,674	4,645	2,992	1,450	603	664	16,124	5,248	3,656	20,502	6,861	5,269	74	23
Total	1,936	1,129	22,616	8,762	24,550	9,891	116,057	36,872	26,670	11,004	5,734	5,795	127,061	42,606	30,465	15,154	52,497	40,356	73	23
Brown County																				
Total	-	108	-	750	-	858	-	4,382	2,897	-	930	930	-	5,312	3,827	-	6,170	4,685	-	24
Dane County																				
Total	-	289	-	1,382	-	1,671	-	7,337	4,865	-	1,302	1,302	-	8,639	6,167	-	10,310	7,838	-	24

*No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

TABLE 12. SUMMARY OF DAILY CARBON MONOXIDE EMISSIONS (kg/day)

County	Heavy-duty trucks						Light-duty vehicles									All vehicles				
	1977 diesel	1987 diesel	1977 gasoline	1987 gasoline	1977 total	1987 total	1977 auto	1987 without I/M auto	1987 I/M auto	1977 LD-truck	1987 without I/M LD-truck	1987 I/M LD-truck[a]	1977 total	1987 without I/M total	1987 I/M total	1977	1987 without I/M	1987 I/M	Percent reduction 1977-1987 I/M	Percent reduction 1987-1987 I/M
Milwaukee - Seven-County Metropolitan Area																				
Kenosha County, freeway and arterials	1,481	1,174	9,231	6,741	10,712	7,915	49,399	22,006	11,709	4,352	3,997	3,997	53,951	26,003	15,706	64,663	33,918	23,621	64	30
Milwaukee County, freeway and arterials	2,362	2,404	105,000	76,139	107,362	78,543	309,848	143,141	76,285	28,080	21,077	21,078	337,928	164,218	97,363	445,290	242,761	175,906	61	28
Ozaukee County freeway and arterials	964	719	6,350	4,816	7,314	5,535	26,071	11,998	6,372	2,075	1,799	1,799	28,146	13,797	8,171	35,460	19,332	13,706	61	29
Racine County, freeway and arterials	1,018	996	15,872	10,884	16,890	11,880	64,834	26,469	14,082	6,448	4,597	4,597	71,282	31,066	18,679	88,172	42,946	30,559	65	29
Walworth County, freeway and arterials	967	963	10,912	8,246	11,879	9,209	26,227	12,933	6,868	3,912	3,409	3,408	30,139	16,342	10,276	42,018	25,551	19,485	54	24
Washington County, freeway and arterials	787	802	9,364	7,556	10,151	8,358	31,003	13,566	7,212	4,231	3,879	3,885	35,234	17,445	11,097	45,385	25,803	19,455	57	25
Waukesha County, freeway and arterials	1,413	1,129	42,038	32,990	43,451	34,119	104,409	46,416	24,949	11,479	9,931	9,931	115,888	56,347	34,880	159,339	90,466	68,999	57	24
Seven-County local	2,643	239	37,298	20,367	39,941	20,606	124,331	42,428	22,699	10,926	6,861	6,861	135,257	49,289	29,560	175,198	69,895	50,166	71	28
Total	11,635	8,426	236,065	167,739	247,700	176,165	736,122	319,457	170,176	71,723	55,050	55,056	807,845	374,507	225,732	1,055,545	550,672	401,897	62	27
Brown County																				
Total	-	825	-	12,431	-	13,256	-	38,919	20,747	-	9,543	9,543	-	48,462	30,290	-	61,718	43,546	-	29
Dane County																				
Total	-	2,163	-	24,674	-	26,837	-	63,244	33,639	-	12,867	12,867	-	76,111	46,506	-	102,948	73,343	-	29

[a] No reduction in light-duty truck emissions was calculated because the credits for this particular vehicle category have yet to be established by EPA. Appropriate adjustments will be made when the credits are made available.

Keeping these in mind, some interesting facts and figures on I/M fuel savings may then be quoted. The U.S. Department of Transportation in the "Department of Motor Vehicle Diagnostic Inspection Program (DMVDIP)" projected nationwide impacts of I/M related fuel savings. These show a resulting conservation of 1.8 billion gallons of gasoline/year or $1.1 billion saved by consumers. While the accuracy of this estimate is open to speculation, its magnitude is impressive. Hamilton Test Systems has noted a decrease in vehicle failure in the field, thus saving vehicle owners towing charges as well as other related expenses. The EPA has noted that improvement in fuel economy is greatest when the failure rate is minimized. This occurs because lowering the stringency rate isolates those vehicles most in need of repairs.

An estimate of the fuel savings resulting from implementation of I/M in nine counties in Wisconsin can be made based on several assumptions. Setting the program's stringency rate at 30 percent, assuming the average increase in fuel economy is 7 percent for failed vehicles and that daily VMT in these counties is 36,305,655 yields a reasonable estimate of potential fuel savings in 1987. Correcting VMT to reflect the LDV population minus those LDVs exempt from program coverage (over 12 years old) the program will realize a fuel savings on the order of 8,642,000 gallons over the year 1987. If fuel costs $.70 per gallon in 1987 this reduction results in a savings to motorists of $6,049,400 for that year.

Since the stringency rate is a policy variable that will have a substantial impact on fuel savings accruing from the program, Table B-3 in Appendix B presents fuel savings estimates for stringency rates varying from 10 to 50 percent. I/M programs have not been of sufficient duration to accurately assess the actual magnitude of fuel improvements that will be experienced by failed (and subsequently repaired) vehicles, therefore Table B-3 also varies this factor between 2 and 10 percent. In addition to reporting these estimates, Appendix B presents the methodology used to generate the 1987 fleet mileage estimate and the determination of what portion of LDV VMT are generated by vehicles less than 13 years old.

COST CONSIDERATIONS

The technique used in developing the cost analysis was to focus on specific cost categories so that very elemental comparisons among programs would be possible. The specific cost categories, and elements thereof, that were used are outlined in Table 13.

All the costs specified in Table 13 are reported in 1978 dollars. At this stage of the analysis, inflation is assumed to be nonexistent.

Initial Capital Costs

These costs reflect the initial outlay of money required for the design and implementation of a program. These costs are very sensitive to the type of program selected as well as to the specific features incorporated into any particular option. As indicated in Table 13, there are three primary elements associated with these costs.

TABLE 13. OUTLINE OF PROGRAM COST CATEGORIES AND ELEMENTS

Primary category	Principal Element	Items included
I. Initial Capital Costs	1. Land investment	a. Actual land cost
		b. Pavement and landscaping
	2. Building investment	a. Construction cost
	3. Equipment costs	a. Primary test equipment
		b. Ancillary equipment
		c. Office equipment/furnitures
		d. Maintenance equipment
II. One-Time Start-Up Costs	1. Land acquisition	a. Site location studies
		b. Title transfer costs
	2. Facilities planning	a. Design study
		b. Bid evaluation
		c. Construction monitoring
	3. Program design	a. Develop equipment specifications
		b. Develop subprograms (e.g., public information, surveillance, quality control, enforcement, etc.)
		c. Define personnel organizational structure
		d. Define data handling needs
		e. Plan program effectiveness studies
	4. Develop data handling systems software	
	5. Personnel training	a. Inspectors
		b. Managers
		c. Quality control personnel
	6. Personnel salaries and overhead prior to start-up	
	7. Initial public information program	
III. Annual Operating Costs	1. Facility personnel	a. Wages, benefits, etc.
	2. Maintenance	a. Equipment
	3. Utilities/services/supplies	a. Electric
		b. Heat
		c. Insurance
		d. Miscellaneous
		e. Taxes
IV. Annual Administrative Costs	1. Program administrative personnel	a. Wages, overhead
	2. Enforcement	
	3. Consumer protection/quality Assurance	
	4. Public information	
	5. Training, licensing, certification	

Land Investments--

A number of issues beyond the obvious one of land area are extremely crucial in estimating land costs. The basic unit cost, for example, is in most instances, lot-specific to the extent that the cost per square foot within any block may vary by a factor of 3; within any city or town, the cost may vary by a factor of 10 or more. It is obvious, then, that a precise unit cost for land cannot be provided here. Alternatively, estimates were developed by the Wisconsin Department of Transportation, Bureau of Real Estate, based on the general requirements for each option specified by GCA regarding size, access, zoning, etc., for each county and in some instances for specific municipalities within counties. These estimates, shown in Table 14, reflect early 1978 average market value of commercially zoned land located along major arterial streets.

TABLE 14. ESTIMATED VALUE FOR COMMERCIALLY-ZONED LAND IN NINE WISCONSIN COUNTIES

County	Municipality/area	Estimated value* ($/ft^2)
Brown	Green Bay	1.70
	Suburbs	1.00
Dane	Madison	2.00
	Suburbs	1.00
Kenosha	Kenosha	1.70
Milwaukee	Milwaukee	1.50
Ozaukee	Cedarburg	0.60
Racine	Racine	0.75
Walworth	All	0.67
Washington	West Bend	0.85
Waukesha	Brookfield	2.50
	Muskego	1.85
	Waukesha	2.30

*Source: Wisconsin Department of Transportation, Bureau of Real Estate.

That these estimates represent an average of a fairly wide range in actual unit costs is acknowledged here and should be borne in mind in comparing these with lot-specific estimates, which, undoubtedly, will be developed in subsequent studies if a centralized inspection option is selected.

Improvements to the land are also included in this category. This involves primarily pavement and landscaping. Estimates provided by the Bureau of Real Estate indicated that the unit costs for pavement and landscaping are approximately \$0.80 per square foot and \$0.25 per square foot, respectively.

Building Investments--

Building costs are obviously dependent on specific designs and features utilized, therefore the unit costs, generally on a dollar-per-square foot basis, can be expected to vary somewhat. For the centralized facility options being considered here, a general design description was developed and submitted to the Wisconsin Department of Transportation, Bureau of Real Estate, for an assessment of the likely unit cost. The general building design calls for a clear span, metal structure, utilizing metal sandwich panel walls with normal wall and ceiling finish for the administrative areas, and no wall or ceiling finish in the inspection area. Equipment such as an air exchange and forced hot air heaters in the inspection area, and central heating and air-conditioning in the administrative areas are also included. No provisions are made for specialized systems such as exhaust fume collection, etc.; these are included in the equipment costs.

Based on the general design features described above and on the building size requirements, the Bureau of Real Estate estimated that the cost of constructing the buildings required for centralized test facilities would be $25 per square foot. This value was used in the cost evaluations developed here.

Equipment Costs--

The equipment cost estimates used in this study were developed primarily from interviews with manufacturer's representatives. These interviews focused on identifying the most appropriate type and model for various major items and determining the general level of skill required to operate and maintain each. Specific costs are presented in the detailed discussion of each option.

One-Time Start-Up Costs

Implementation of an I/M program will require the expenditure of monies for noncapital items and services on a one-time basis prior to the actual start-up. Costs associated with this category are perhaps the most difficult to define at this point primarily because the elements involve services (program planning, design, and development), which are inherently much more variable in cost than, for instance, equipment or land costs. This is especially true for this analysis where a specific scope for these services has not been developed. Considerations used in developing cost estimates for each element are discussed below.

Land Acquisition--

Included in this element are the costs for locating candidate sites, negotiating the purchase, and completing title transfers. Costs for locating and negotiating the purchase of land reflect personnel time requirements of approximately 200 man-hours of professional technical time, plus 40 hours of professional legal time for each site. To translate the man-hours to cost, a $20-per-hour and $50-per-hour value were assigned to the technical and legal hours, respectively; this represents a total cost of $6,000 per site for this component. The final component - title transfer - is considered to include physical surveys, title searches, site plan preparation, and miscellaneous support functions required to execute the purchase. The cost associated with this component was assumed to be 10 percent of the purchase price of the land.

Facilities Planning--

This element reflects the costs associated with engineering and design for the test facilities, bid review, and construction monitoring. The value of these services was estimated as a function of the total building cost for each option. Specifically, for total building construction costs of up to $3 million, a value of 20 percent of the construction cost estimate was used; for building costs of $3 million to $6 million, 15 percent of the cost was used, while for building costs greater than $6 million, 10 percent was used.

Program Design--

This element reflects the cost of additional planning studies required to establish specific formats for the operation and administration of both the actual inspection program and adjunctive programs such as public information. These costs are, again, likely to be quite variable depending on factors such as the extent of in-house effort undertaken by the State; the relative cost is expected to vary somewhat as a function of the particular option selected. In deriving an estimate, the experiences of other states were considered primarily to complement our analyses.

Data Handling Software--

Regardless of the option selected for implementation, a data software package will be required to provide both basic recordkeeping and program analysis functions. The estimates developed were based largely on both the experiences of various states and conversation with representatives of commercial data processing firms.

Personnel Training--

Although personnel training will require an ongoing effort, an initial, highly intensive program must be undertaken to essentially train and certify both the entire staff of inspectors and managerial personnel, as well as mechanics from the private sector who will be performing the required maintenance. It is noted that the maintenance phase of I/M programs is generally phases such that the first several months include voluntary maintenance; therefore, the intensity required to train mechanics is somewhat less than that for inspectors.

To develop cost estimates for training, it was considered that a logical approach would be for the State to provide instructors who would be trained at workshops or through vocational education programs designed specifically to meet the requirements of I/M. These instructors, then, would provide training for the actual inspectors and mechanics. Programs designed specifically for this type of an approach are available from the Colorado State University through the U.S. Environmental Protection Agency.

Cost estimates were developed based on information obtained from the literature and directly from Colorado State University. The training costs associated with the private garage option are likely to be higher than for the others. The primary reasons for this are that (1) more inspectors/mechanics will have to be trained, and (2) special facilities and equipment will have to be provided for training. The training considers three technical levels, including: (1) instructors, (2) investigators, and (3) inspector/mechanics.

Based on a 40-hour program for both instructors and investigators, and a 12-hour program for inspectors/mechanics, the estimated per person cost of training, respectively, is $74.00, $59.00, and $22.00 for the private garage option. If centralized inspection facilities were used for training, the cost per instructor, investigator, and inspector/mechanic would be $53.00, $43.00, and $16.00, respectively.

Personnel Salaries--

The literature and interviews with both officials from states with existing I/M programs and private contractors involved in I/M program operation, indicate that for centralized programs, the managerial, support, and technical personnel should be phased into the program prior to beginning mandatory inspection. This phase-in would bring managerial personnel in 6 months prior to startup, while inspectors would begin 1 month before the mandatory phase. Support personnel would be phased-in throughout this period. During this period, personnel would become familiar with their specific job functions and general procedures. This phase could include voluntary inspection, which would provide a realistic working environment without the stress of maintaining a rather rigid production schedule as required during the mandatory phase. This phase serves as a "shake-down" period for the equipment and test itinerary, as well.

The personnel cost of the first month operation, then, is included in the one-time start-up cost category for operations personnel (technical, managerial, and support) for centralized facility options. There is no parallel requirement for the private garage option.

The state administrative personnel function would begin 30 months and 18 months prior to start-up for the state-operated and contractor-operated centralized facility options, respectively. For the private garage option, administration at the state level would begin 30 months prior to start-up.

Initial Public Information Program--

The experience thus far with I/M program operation shows that there is a definite requirement for a rather vigorous public information effort prior to program start-up. While there are no specific requirements defined regarding the lead-time necessary or the program content and budgetary requirements, the general experience indicates that it would be reasonable to expect that the effort should begin anywhere from 6 to 12 months prior to start-up, and that a preimplementation budget based on $0.10 to $0.12 per vehicle (to be inspected) is warranted. These general assumptions were used in deriving an estimate of the initial public information program requirements for Wisconsin; it is noted that the program requirements are essentially identical for all six options under consideration here.

Annual Operating Costs

Annual operating costs include all costs associated with the actual operation of the program. For the purposes here, the costs of adjunctive programs such as ongoing public information and inspector/mechanic training programs are not included; rather, the costs associated with these programs are classified as annual administrative costs, which are discussed later.

Facility Personnel--

Determinants of costs associated with the operation of the inspection facilities are (1) the total number of individuals and relative level of job responsibility, and (2) the per-unit personnel cost including both wages and overhead.

In computing the personnel costs, the actual number of persons required by skill level was derived for each option based on the specific level of work effort associated with the particular option. The per-hour wage rate for various categories was derived from data obtained from the State of Wisconsin Bureau of Personnel, Department of Administration, and the overhead estimates were based on data from the U.S. Department of Labor and State data, and from conversations with private contractors involved in operating I/M programs. The hourly overhead rate was determined to be 25 percent of the basic hourly wage rate.

Maintenance--

Costs associated with equipment maintenance and upkeep were based on the experience of other states. In this connection, it was found that these costs represent approximately 20 percent of the original equipment costs.

Calibration Cost--

The costs for calibration of emission analyzers are composed of the calibration/maintenance people salaries, the calibration runs, annual operating expenses for the runs (fuel, maintenance, insurance, etc.) plus the cost of calibration gases. The first two elements are discussed under operating personnel costs and equipment costs, respectively. The annual insurance and fuel costs were assumed to be $1,000 each annually, and the cost of calibration gases was obtained from a supplier.

Utilities/Services/Supplies--

Included in this element are the costs associated with electricity, heat, water, building services, insurance, office supplies, inspection forms, etc. These costs were estimated based on several sources concerning equipment and facility power requirements determined from manufacturers and the general literature and the prevailing utility rates in the state, average heating requirements data for similar facilities, insurance costs and general building service requirements from existing programs.

Annual Administrative Costs

The costs included in this category reflect the overall program administration effort. Specifically, the salaries of personnel involved in areas such as enforcement, consumer protection, public information, and training, licensing, and certification are included. For the private garage option, an additional item - data handling - becomes important since the effort is largely manual. The centralized facilities utilize a high degree of automation, therefore, data handling costs are reflected as utility and service costs, which are included as operating costs.

TOTAL COST METHODOLOGY

In order to compare costs among various alternatives, the costs appearing in Table 13 are converted into annual figures. Appendix E contains a complete description of the methodology used. The more salient points follow.

Initial Capital Costs

The primary elements associated with this category are the costs associated with land, buildings, and equipment. These costs were computed in constant 1978 dollars using appropriate amortization factors.

Since land yields services in perpetuity, the amortization factor is assumed to be the marginal rate of return on capital. This factor, then, is sensitive to the source of financing (i.e., equity, debt, or taxes). For this analysis, a factor of 0.06 is assumed.

Structures are assumed to have a 20-year service life and to yield equal service throughout this period. The annual cost of each dollar invested in structures, then, is: $\frac{1}{1-(1+i)^{-20}}$

Similarly, equipment is assumed to provide service for 5 years, thus the annual cost per dollar invested in equipment is: $\frac{1}{1-(1+i)^{-5}}$

One-Time Startup Costs

One-time startup costs, like capital costs, are incurred only during initial startup. The startup costs are recouped over the first 5 years of the project. Thus, the annual cost of each dollar of expenditure is the same as that for capital equipment, $\frac{1}{1-(1+i)^{-5}}$

Annual Operating and Administrative Costs

These costs are already presented as annual amounts. These amounts must be added to the annualized capital and startup costs, to arrive at the total annual cost of the whole project.

Fee Calculations

A fee, f_c, is calculated by dividing total annual costs by the number of paid inspections per year. This fee, along with all other costs, is expressed in real 1978 dollars. To get figures in actual dollars for years other than 1978, costs and fees must be increased by the amount of inflation since 1978.

Interest rates used with real or constant dollar calculations reflect the real return on capital. Actual interest rates include compensation to offset the diminished buying power of money under inflation, and thus, are inappropriate here.

In the Appendices, another fee, (f_a), is presented. This fee is also expressed in 1978 dollars; however, it is uniform in actual dollars and will not increase with inflation for 5 years after the program begins.

PERSONNEL REQUIREMENTS

The basic requirements of an I/M program call for both operating and administrative personnel. Operating personnel are those directly involved in performing inspections or providing managerial functions at the inspection site. Administrative personnel are involved in operating support programs such as enforcement and quality control, or in providing overall program management and administration.

Operating Personnel

This category is the more sensitive to a specific option than is the administrative category. The basis for determining the requirements for operating personnel include both analyses of tasks associated with each element on the program options, and the experiences of programs currently in operation. In general, the manpower allocation for centralized facilities consists of (1) three inspectors per lane for emission inspections or four inspectors per lane for combined emission, safety and noise inspection, (2) one manager and one assistant manager for each facility, and (3) one equipment maintenance person for every three emission inspection facility or for every two facilities for the combined emission, safety, and noise option. Specific manpower requirements for each option are delineated in the sections discussing each option in detail. The requirements for the private garages are entirely different and will also be discussed in the report section describing the private garage option.

Administrative Personnel

A scenario of the administrative personnel requirements was developed based on the overall scope of each option, including geographic coverage and level of operational activity. The actual requirements are not expected to vary substantially among options since the relative scope of the program defined by each option does not vary to any extent.

A schematic diagram of the organizational network is presented in Figure 2. This figure indicates that the I/M program would be coordinated by an administrator who would oversee actions of supporting services and station operations sections. Each of these sections would be headed by respective assistant administrator. The supporting services assistant in addition to supervising the legal, financial, engineering, and mechanic training officers, would be responsible for assisting the administrator in policy decisions. The station operations assistant would supervise regional managers and be directly responsible for overseeing the operation of state-operated challenge lane facilities (if utilized).

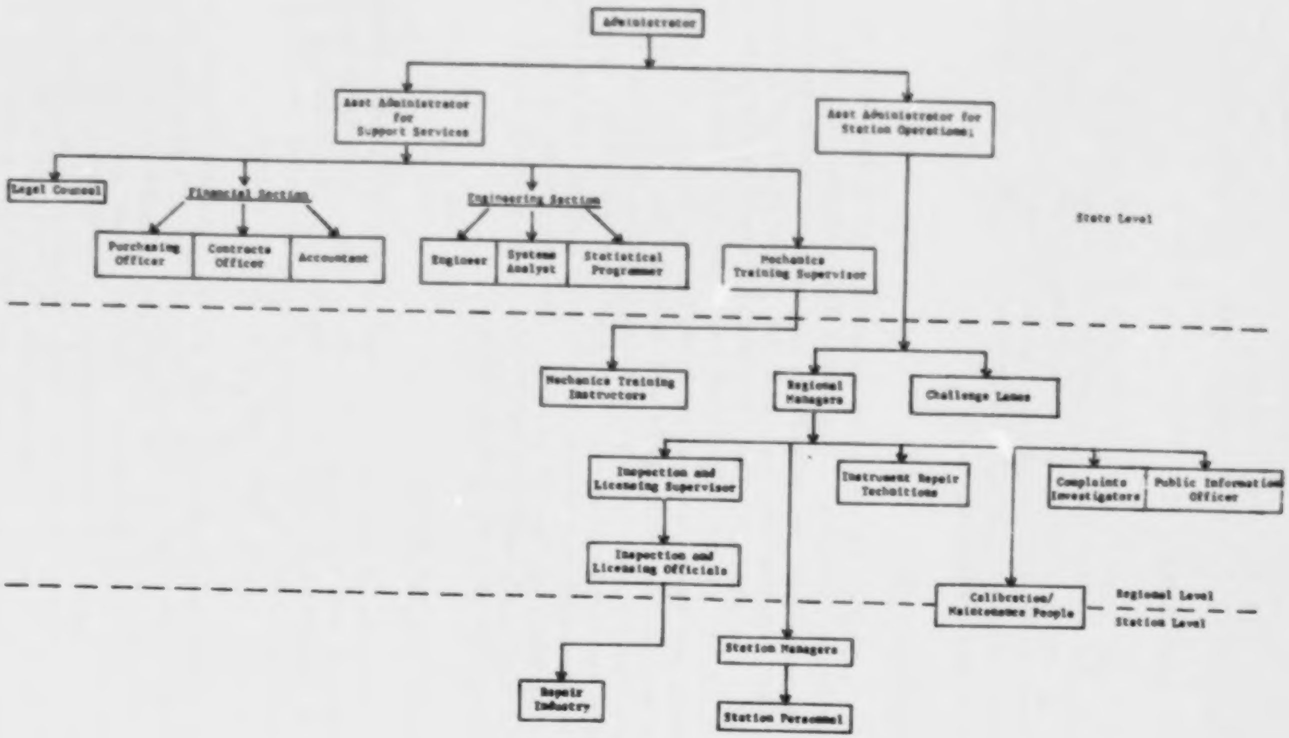
Administrator
Asst Administrator for Support Services
Asst Administrator for Station Operations
Legal Counsel
Financial Section
Purchasing Officer
Contracts Officer
Accountant
Engineering Section
Engineer
Systems Analyst
Statistical Programmer
Mechanics Training Supervisor
State Level
Mechanics Training Instructors
Regional Managers
Challenge Lanes
Inspection and Licensing Supervisor
Instrument Repair Technicians
Complaints Investigators
Public Information Officer
Inspection and Licensing Officials
Calibration/ Maintenance People
Regional Level
Station Level
Station Managers
Repair Industry
Station Personnel

Figure 2. Administrative Organization.

The legal counsel position, probably handled by the State of Wisconsin Attorney General's Office, would assist the administration in interpretation of any legal issues that might arise in the operation of the program.

The financial section of supporting services would consist of three positions: (1) a purchasing officer, (2) a contracts officer, and (3) an accountant. The purchasing officer, in addition to handling actual acquisition of equipment and supplies, would be responsible for formulation of current and future budget requirements.

The contracts officer would be responsible for negotiation and review of all contracts necessary to I/M system construction and operation. The accountant would be in charge of keeping records of all financial transactions involved in the system operation, possibly including receipt of registration fees from motorists.

The engineering section would consist of three positions: (1) a systems engineer, (2) a systems analyst, and (3) a statistician/programmer. The systems engineer formulates and reviews standards for inspection and stringency rates. The systems analyst reviews system performance and develops more efficient system operations methodology.

The statistician/programmer would perform statistical analyses and tabulations required for evaluation of station, regional, or statewide operations and design and update software for data handling.

The mechanics training program coordinator would be responsible for the hiring and education of instructors, arranging training programs, and devising tests for licensing of inspectors and repairmen.

The regional managers would supervise operation of all I/M inspection facilities within each geographic district (to be later defined), direct surveillance of operations and calibration of test equipment, as well as preparing budget requirements of the specific region.

The regional inspection and licensing supervisor would be responsible for certification of repair facilities, and assuring that repair industry analyzers are in proper calibration and working order. Serving under this position would be inspection and licensing officials.

The regional complaints investigator would be responsible for following up on consumer complaints in the geographic region.

The regional Public Relations Coordinator would serve as spokesperson for the program and provide the public with information to assure participation and support of I/M.

The mechanic training program instructor would develop and conduct classes for mechanics and conduct certification testing.

The instrument repair technician would be responsible for equipment repairs.

Personnel Costs

The costs for operating and administrative personnel were derived from Classification and Compensation Plan 1977-1978, Department of Administration, State Bureau of Personnel. Salaries were matched with position classifications most closely matching job descriptions of the positions previously defined. Salary levels used were those for "starting" personnel. There is one notable exception. The station managers duties included considerably more than the most comparably listed state position. Specifically, the manager would be involved in many aspects of computer operation necessary in a highly automated facility. It was for this reason that the station managers salary was assumed started at 25 percent more than the comparable position classification. Salaries by position are shown in Table 15.

In addition to salaries, a 25 percent overhead charge was added to cover employee benefits, employer charged social security taxes, and paid legal holidays.

TABLE 15. ESTIMATED HOURLY STARTING SALARIES FOR ADMINISTRATIVE AND OPERATIONAL PERSONNEL INVOLVED IN INSPECTION AND MAINTENANCE PROGRAMS IN WISCONSIN

I/M job title	State classification	Hourly salary ($)
Administrator	Administrative Officer 5	12.91
Assistant Administrator for supporting services	Administrative Assistant 5 (MGT)	8.39
Assistant Administrator for station operations	Administrative Officer 3 or Administrative Officer 4	10.87 11.85
Legal Counsel	Attorney (all types start at:)	7.47
Purchasing Officer	Purchasing Agent 1	6.54
Contracts Officer		
Accountants	Account Examiner 1 or Accountant 1	3.85 6.05
Engineer	Environmental Engineer 1 or Engineering Technician 1	6.68 5.21
Systems Analyst	Research Analyst 1 or Research Analyst 2	5.42 5.78
Statistician/Computer Programmer	Program Writer-Producer	5.26
Mechanic Training Program Coordinator	Program Coordinator or Training Officer 1	7.09 6.54
Regional Manager	Administrative Officer 3 or Administrative Officer 4	10.87 11.85
Regional Inspection and Licensing Supervisor	Motor Vehicle Investigation Supervisor 3 or Motor Vehicle Investigation Program Assistant	7.70 6.25
Regional Complaints Investigator	Public Information Officer 4 or Public Information Officer 1	7.70 4.92
Regional Public Relations Coordinator	Public Information Officer 4	7.70
Mechanic Training Program Instructor	Teacher I or Mechanician I	5.36 5.21
Instrument Repair Technician	Maintenance Mechanic 3	5.91
Inspection and Licensing Official	Motor Vehicle Investigation Supervisor 2, or Motor Investigation Supervisor 3	7.10 7.70

(continued)

TABLE 15 (continued)

I/M job title	State classification	Hourly salary ($)
Inspection Station Supervisor	Motor Vehicle Investigation Supervisor 3	7.70
Inspection Station Supervisor	Motor Vehicle Investigation Supervisor 3	7.70
Motor Vehicle Inspector	Motor Vehicle Inspector 1	5.21
Clerk - Inspection Station	Clerk 1 Clerk 2	3.12 3.46
Inspection Station Maintenance Person	Custodial Supervisor 1	4.60
Secretary/Typist	Typist 3 Supervisor (no secretary listing)	4.06
Clerk - Office	Clerk 1 Clerk 2	3.12 3.46
Keypunch Machine Operator	Data Processing Machine Operator I	3.46
Lane Supervisor	Motor Vehicle Inspector 3	6.05

Note: Contact for this information:
Mike Soehner
Bureau of Personnel
Wisconsin
(608) 266-3626

SECTION 4

OPTION 1 - CENTRALIZED, CONTRACTOR-OPERATED, LOADED-MODE WITH SAFETY AND NOISE TESTING

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized emission, safety, and noise inspection stations throughout the nine-county area defined in Section 2. The emission inspection would involve loaded-mode testing of light-duty, gasoline-powered vehicles less than 13 years old, on an annual basis.

The safety inspection would apply to all light-duty vehicles regardless of age or fuel used. As a minimum, safety inspections would focus on (1) dynamic brake testing; (2) visual and measured tire and wheel inspection; (3) visual inspection of suspension components and dynamic steering tests; (4) visual lamp function and mechanical headlamp aiming; (5) visual glazing; (6) visual body and sheet metal; and (7) visual exhaust system.

Noise inspections would be conducted on all vehicles undergoing safety inspection. The primary focus of the noise inspection would be to ensure that vehicles are equipped with adequate muffler systems.

NETWORK REQUIREMENTS

Two factors are critical in the analysis of network requirements for any option. The first factor is the size of the vehicle population to be tested. Motor vehicle registration data for 1977 by county and by vehicle type were provided by the Wisconsin Department of Transportation (WDOT) as shown in Table 16. For this analysis, the system requirements as of 1990 are of interest, therefore projections of vehicle registration to 1990 were derived by assuming a steady 3 percent annual growth rate in the motor vehicle population and applying the growth rate to the 1977 data. Although county "vehicles available" data were obtained from the Southeastern Wisconsin Regional Planning Commission (SEWRPC), comparisons with actual registration data indicated that the projected growth rates used by SEWRPC were too low, and that a 3 percent rate was appropriate. The projected 1990 vehicle registration for light-duty cars and trucks, by county, are shown in Table 17.

The assumed stringency factor throughout this analysis is 30 percent, meaning that 30 percent of all vehicles tested will fail, by design. Assuming that all failed vehicles would have to be retested, the number of inspections to be performed is actually 30 percent higher than the actual number of individual vehicles required to participate in the program. The actual number of

TABLE 16. 1977 MOTOR VEHICLE REGISTRATIONS BY COUNTY - LDV AND LDT ONLY

County	1977 LDV registrations	1977 LDT registrations	Total
Brown	77,564	11,503	89,067
Dane	148,718	19,030	167,748
Kenosha	57,254	8,131	65,385
Milwaukee	454,181	34,722	488,903
Ozaukee	33,867	3,507	37,374
Racine	82,500	10,310	92,810
Walworth	33,104	5,892	38,996
Washington	37,250	5,691	42,941
Waukesha	135,430	17,285	152,715
Total	1,059,868	116,071	1,175,939

TABLE 17. PROJECTED 1990 LDV AND LDT REGISTRATIONS BY COUNTY

County	Total LDV's and LDT's
Brown	131,000
Dane	246,000
Kenosha	96,000
Milwaukee	718,000
Ozaukee	55,000
Racine	136,000
Walworth	57,000
Washington	63,000
Waukesha	225,000
Total	1,727,000

inspections, then is equal to 1.3 times the affected population, as shown in Table 18.

TABLE 18. ANNUAL NUMBER OF INSPECTIONS REQUIRED BY COUNTY FOR 1990

County	Number of annual inspections
Brown	170,000
Dane	320,000
Kenosha	125,000
Milwaukee	933,000
Ozaukee	72,000
Racine	177,000
Walworth	74,000
Washington	82,000
Waukesha	293,000

By making various assumptions about the throughput capabilities of a single lane, the number of such lanes required for each county can be derived. Assume:

1. One vehicle can be inspected every 4 minutes.
2. An inspection facility is open for business 48 hours per week, 52 weeks per year.
3. An efficiency factor of 0.67 to account for random arrival of motorists, equipment downtime, etc.

Then the number of vehicles that can be inspected by one lane per year is:

$$= (15 \text{ cars/hour})(48 \text{ hrs/week})(52 \text{ weeks/yr})(0.67) =$$

$$25{,}085 \text{ vehicles}$$

By dividing the number of inspections by this per-lane annual throughput figure, the number of lanes required in each county is obtained.

A detailed analysis of the individual tasks associated with the testing scenario for Option 1 indicates that the throughput time is 4 minutes. This means that the annual capacity for each inspection lane is 25,085 vehicles, as indicated above. The number of lanes required in each county, then, is the number of annual inspections required divided by the lane capacity; the actual lane requirements are shown in Table 19.

TABLE 19. TOTAL INSPECTION LANES REQUIRED TO SATISFY 1990 INSPECTION DEMAND

County	Number of lanes required
Brown	7
Dane	12
Kenosha	5
Milwaukee	35
Ozaukee	3
Racine	7
Walworth	3
Washington	3
Waukesha	11
Total	86

The desirable allocation of inspection lanes throughout each county (that is, the number of separate inspection facilities) was determined based on identifying the lane requirements for (1) the county seat, and (2) the rest of the county, using the following guidelines:

1. single-lane stations should be avoided owing to the relatively low level of cost-effectiveness compared to multilane facilities; and

2. the maximum station size should be limited to six lanes owing to the excessively high cost of, and probable difficulty in, acquiring parcels large enough to accommodate facilities beyond six lanes.

Lane facilities required to handle county seat populations were sited within the county seat, while the remaining facilities were sited in towns or cities that are most accessible to the remainder of the county. The resulting distribution of facilities by size and by location (municipality) is shown in Table 20.

OPTION COSTS

The costs associated with the implementation and operation of this option are presented here. Reference should be made to the discussion in Section 3 concerning the analytical techniques used.

Capital Costs

As indicated in the discussion presented in Section 3, the types of buildings that are likely to be used are estimated to cost $25 per square foot to construct, regardless of which of the centralized facility options is considered. The problem, then, in developing an estimate of the building cost

TABLE 20. INSPECTION NETWORK REQUIREMENTS FOR OPTION 1

County	Town	Number of facilities	Configuration
Brown	Green Bay	1	3-lane
	Bellevue	1	4-lane
Dane	Madison	2	4-lane
	Suburbs	1	4-lane
Kenosha	Kenosha	1	2-lane
	Bristol	1	3-lane
Milwaukee	Milwaukee	5	6-lane
	Greenfield	1	5-lane
Ozaukee	Cedarburg	1	3-lane
Racine	Racine	1	4-lane
	Rochester	1	3-lane
Walworth	Elkhorn	1	3-lane
Washington	West Bend	1	3-lane
Waukesha	Brookfield	1	6-lane
	Waukesha	1	5-lane
Total network		20	86 lanes

for any specific option is reduced to one of defining the basic size of the building.

For this option, an analysis of the specific inspection tasks (including equipment required) was made to define the general features required of an inspection facility. Literature searches and interviews with individuals involved in operating similar programs, were then conducted, which resulted in being able to define the specific building requirements and to dimension the various work areas. A conceptual floor plan for the basic type of facility required for safety, noise, and emission testing is shown in Figure 3. Although Figure 3 shows a one-lane facility, the total floor area for a multilane facility would increase primarily by the single inspection-area floor space, times the number of inspection lanes; additional space for waiting areas, rest areas, etc., would also be required. Table 21 shows the building area requirements for facility configurations ranging from one to six lanes.

The cost, then, is computed as the product of (1) the building area, and (2) the unit cost, assumed here to be $25 per square foot. The actual cost estimate for the facilities defined in Table 20, then, can be computed. These are shown in Table 22.

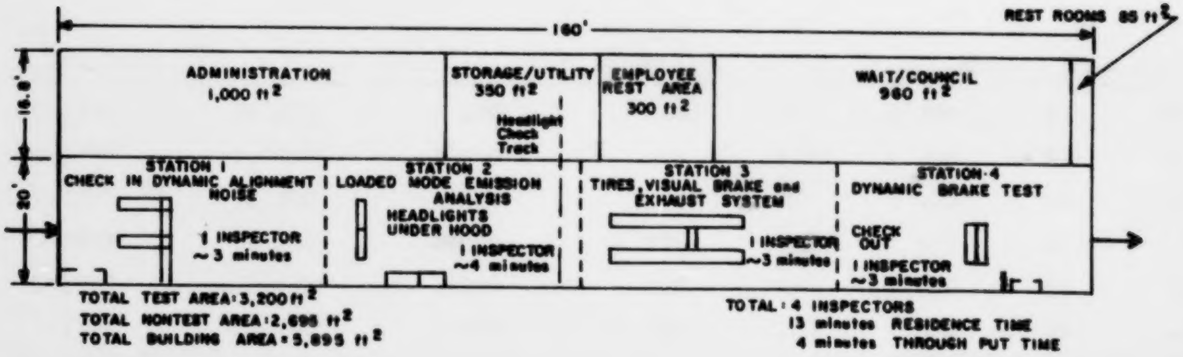
160'
REST ROOMS 85 ft²
16.8'
20'
ADMINISTRATION
1,000 ft²
STORAGE/UTILITY
350 ft²
Headlight Check Track
EMPLOYEE REST AREA
300 ft²
WAIT/COUNCIL
960 ft²
STATION 1
CHECK IN DYNAMIC ALIGNMENT NOISE
1 INSPECTOR
~3 minutes
STATION 2
LOADED MODE EMISSION ANALYSIS
HEADLIGHTS
UNDER HOOD
1 INSPECTOR
~4 minutes
STATION 3
TIRES, VISUAL BRAKE and EXHAUST SYSTEM
1 INSPECTOR
~3 minutes
STATION 4
DYNAMIC BRAKE TEST
CHECK OUT
1 INSPECTOR
~3 minutes
TOTAL TEST AREA: 3,200 ft²
TOTAL NONTEST AREA: 2,695 ft²
TOTAL BUILDING AREA: 5,895 ft²
TOTAL: 4 INSPECTORS
13 minutes RESIDENCE TIME
4 minutes THROUGH PUT TIME

Figure 3. Conceptual floor plan for a combined safety, noise, and loaded-mode emission inspection facility.

TABLE 21. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS - OPTION 1

Configuration	Floor area required (ft^2)						
	Test area	Administration	Employee rest	Storage	Waiting	Restrooms	Total
1-lane	3,200	1,000	300	350	960	85	5,895
2-lane	6,400	1,000	350	400	1,440	85	9,675
3-lane	9,600	1,000	410	450	2,240	85	13,785
4-lane	12,800	1,000	450	500	3,360	85	18,195
5-lane	16,000	1,000	500	550	4,800	85	22,935
6-lane	19,200	1,000	550	600	6,560	85	27,995

Land Costs--

The primary determinants of land cost for any option are (1) the unit cost per square foot, and (2) the total size (square feet of the land to be acquired. In Section 3, unit cost estimates for land in each county were presented, and these will be used here.

The lot size requirements are a function of facility size (i.e., the number of lanes). A general relationship exists between the land area required and the size floor area of the test facility; this relationship is that the ratio of land area to building area is approximately 5:1. The building sizes can be defined as a function of the number of inspection lanes; therefore, since the number of facilities by configuration (i.e., number of lanes) has been defined, the land areas for each facility can be defined, as well. The total land costs, then, are presented in Table 23.

A cost for land improvements is added to the basic land cost to obtain the total land investment. The primary elements involved in improvements are paving and landscaping. Based on analyses of parking requirements, standard pavement and landscaped areas have been developed for each type of facility. These are shown in Table 24.

Based on a unit price of $0.80 per square foot and $0.25 per square for paving and landscaping, the improvement costs for each facility type can be computed. These are shown in Table 25. The actual improvement costs associated with each facility are shown in Table 26.

Equipment Costs--

The major equipment items required to operate a combined safety, noise and emissions test facility were identified based on analyses of each inspection task requirements and conversations with individuals currently involved in these types of testing programs. Outlined in Table 27 are the equipment requirements and associated costs for a combined emission, safety, and noise inspection program.

TABLE 22. BUILDING COST ESTIMATES FOR OPTION 1

County	Facility configuration	Per facility cost ($)	Number facilities required	Total cost ($)
Brown	3-lane	344,625	1	344,525
	4-lane	454,875	1	454,875
Dane	4-lane	454,875	3	1,364,625
Kenosha	2-lane	241,875	1	241,875
	3-lane	344,625	1	344,625
Milwaukee	6-lane	699,875	5	3,499,375
	5-lane	573,375	1	573,375
Ozaukee	3-lane	344,625	1	344,625
Racine	4-lane	454,875	1	454,875
	3-lane	344,625	1	344,625
Walworth	3-lane	344,625	1	344,625
Washington	3-lane	344,625	1	344,625
Waukesha	6-lane	699,875	1	699,875
	5-lane	573,375	1	573,375
Total				9,828,500

TABLE 23. LAND COSTS FOR EACH INSPECTION FACILITY IN OPTION 1.

County	Municipality	Facility configuration	Number of facilities	Total building area (ft^2)	Land area (ft^2)	Unit cost of land ($\$/ft^2$)	Total land cost ($)
Brown	Green Bay	3	1	13,785	68,925	1.70	117,173
	Bellevue	4	1	18,195	90,975	1.00	90,975
Dane	Madison	4	2	36,390	181,950	2.00	363,900
	Suburbs	4	1	18,195	90,975	1.00	90,975
Kenosha	Kenosha	2	1	9,675	48,375	1.70	82,238
	Bristol	3	1	13,785	68,925	1.70	117,173
Milwaukee	Milwaukee	6	5	139,975	699,875	1.50	1,049,813
	Greenfield	5	1	22,935	114,675	1.50	172,013
Ozankee	Cedarburg	3	1	13,785	68,925	0.60	41,355
Racine	Racine	4	1	18,195	90,975	0.75	68,231
	Rochester	3	1	13,785	68,925	0.75	51,694
Walworth	Elkhorn	3	1	13,785	68,925	0.67	46,180
Washington	West Bend	3	1	13,785	68,925	0.85	58,586
Warkesha	Brookfield	6	1	27,995	139,975	2.50	349,938
	Warkesha	5	1	22,935	114,675	2.50	286,688
				397,200	1,986,000		2,986,932

TABLE 24. PAVEMENT AND LANDSCAPING REQUIREMENTS FOR OPTION 1 FACILITIES

Facility configuration	Total area	Paved area (ft^2)	Landscaped area (ft^2)
1 lane	29,475	6,620	16,960
2 lane	48,375	13,105	25,595
3 lane	68,925	19,725	35,415
4 lane	90,975	25,940	46,840
5 lane	114,680	32,560	59,185
6 lane	139,980	38,775	73,210

TABLE 25. LAND IMPROVEMENT COSTS FOR INSPECTION SITES UNDER OPTION 1

Facility configuration	Pavement Cost	Landscaping Cost	Total Improvement Cost
1 lane	$ 5,296	$ 4,240	$ 9,536
2 lane	10,484	6,399	16,883
3 lane	15,780	8,854	24,634
4 lane	20,752	11,710	32,462
5 lane	26,048	14,796	40,844
6 lane	31,020	18,303	49,323

TABLE 26. LAND IMPROVEMENT COSTS FOR FACILITIES UNDER OPTION 1.

County	Municipality	Facility configuration	Number of facilities	Cost per facility	Total improvement cost
Brown	Green Bay	3	1	$24,634	$ 24,634
	Bellevue	4	1	32,462	32,462
Dane	Madison	4	2	32,462	64,924
	Suburbs	4	1	32,462	32,462
Kenosha	Kenosha	2	1	16,883	16,883
	Bristol	3	1	24,634	24,634
Milwaukee	Milwaukee	6	5	49,323	246,615
	Greenfield	5	1	40,844	40,844
Ozankee	Cedarburg	3	1	24,634	24,634
Racine	Racine	4	1	32,462	32,462
	Rochester	3	1	24,634	24,634
Walworth	Elkhorn	3	1	24,634	24,634
Washington	West Bend	3	1	24,634	24,634
Waukesha	Brookfield	6	1	49,323	49,323
	Waukesha	5	1	40,844	40,844
					$704,623

The total land investment, then, is $2,986,932 + $704,623 = $3,691,555 .

TABLE 27. MAJOR EQUIPMENT ITEMS REQUIRED FOR OPTION 1

Program element	Item	Remarks	Unit cost ($)
I. Emissions	1. Chassis dynamometer	Needed for loaded-mode emission test. One unit per test lane required. Cost based on conversations with manufacturers (Clayton, Maxwell).	14,000
	2. Emission analyzer	Since loaded-mode is used, analyzer should be capable of measuring CO, HC, and NO_x. Extremely wide range in analyzer costs; cheaper analyzers found to be inadequate. Analyzers should be capable of being tied into computer data handling system. Costs based on discussions with manufacturers (Olson-Horiba, Hamilton Test Systems). One unit per test lane required.	26,500
II. Safety	1. Dynamic brake tester	Analyzes relative and overall braking effort. One required per lane. Costs based on discussion with manufacturer's representative (Clayton, Hofman, Bear, Sun, Maxwell, Weaver).	14,000
	2. Scuff gauges	One required per lane. Cost estimate based on discussion with manufacturer's representative (AAMCO, Weaver).	800
	3. Dynamic alignment	One unit required per lane. Cost estimate based on discussion with manufacturer's representative (Hunter, Dunlop, Bear)	25,000
	4. Headlight-aim photocell	One system required per lane. Cost based on discussion with manufacturer's representative (Hunter, Bear).	625
	5. Chassis lift	One required per lane. Cost based on discussion with manufacturer's representative (AAMCO).	4,000
III. Noise	1. Sound level meter	One required per lane. Cost based on discussions with B&K Instruments and GenRad.	650
IV. Data Systems	1. CRT Terminals	Two required per lane. Costs based on literature and discussions with manufacturer's representatives (Honeywell, Digital, Olivetti, Sperry Univac), and experiences of other states.	2,500
	2. Mini-computer	One required per facility (equivalent to Digital PDP-11-05). Generally assumed to be included in the cost of facility furnishings.	80,000
V. Miscellaneous	1. Miscellaneous tools	As required.	1,000

Equipment costs for any facility configuration, then, can be derived from Table 27. A summary of equipment cost as a function of the facility configuration is shown in Table 28.

TABLE 28. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR OPTION 1

Number of lanes	Equipment cost
1	171,575
2	263,150
3	354,725
4	446,300
5	537,875
6	629,450

The total cost for equipment can now be computed based on the number of facilities by configuration, developed previously. These costs are shown in Table 29. Two additional items must be included with equipment costs; these include calibration vans and equipment, and a central computer. The number of vans is a function of the specific program scope, therefore will vary according to the particular option being considered. Only one computer is required for each option.

For option 1, it is estimated that nine vans would be required. The estimated unit cost for the van* plus calibrating gases and equipment is $14,000. The total cost, then, is $126,000.

A cost of $250,000 for the central computer was suggested by several manufacturers, including Digital, Olivetti, and Sperry Univac.

One-Time Start-Up Costs

Land Acquisition--

Land acquisition costs reflect the effort required to locate and evaluate candidate sites, perform required surveying, negotiate price, and convey title. As explained in Section 3, these costs are computed on the basis of $6,000 per site to cover locating, evaluating, and performing surveys, plus 10 percent of the purchase price to cover the costs associated with conveying the title.

For this option, a total of 20 sites are required reflecting a total land investment (basic cost only) of $2,986,932. The acquisition cost, then, is:

---

* These are $\frac{1}{2}$ - ton light-duty vehicles.

TABLE 29. EQUIPMENT COSTS FOR OPTION 1

County	Town	Facility configuration	Number of facilities required	Equipment cost per facility	Total cost of equipment
Brown	Green Bay	3-lane	1	$ 354,725	$ 354,725
	Bellevue	4-lane	1	446,300	446,300
Dane	Madison	4-lane	2	446,300	892,600
	Suburbs	4-lane	1	446,300	446,300
Kenosha	Kenosha	2-lane	1	263,150	263,150
	Bristol	3-lane	1	354,725	354,725
Milwaukee	Milwaukee	6-lane	5	629,450	3,147,250
	Greenfield	5-lane	1	537,875	537,875
Ozaukee	Cedarburg	3-lane	1	354,725	354,725
Racine	Racine	4-lane	1	446,300	446,300
	Rochester	3-lane	1	354,725	354,725
Walworth	Elkhorn	3-lane	1	354,725	354,725
Washington	West Bend	3-lane	1	354,725	354,725
Waukesha	Brookfield	6-lane	1	629,450	629,450
	Waukesha	5-lane	1	537,875	537,875
					$9,475,450
				Central computer	250,000
				Maintenance/calibration vans	126,000
					$9,851,450

$$(20\ \text{facilities})(\$6{,}000/\text{facility}) + (0.10)(2{,}986{,}932) =$$

$$\$120{,}000 + \$298{,}693 = \$418{,}693$$

Facilities Planning--

This element is computed as a function of the total building construction cost. Specifically, for building construction costs less than $3 million, the facilities planning cost is 20 percent of the construction cost; for costs between $3 million and $6 million, 15 percent is used, and for building costs greater than $6 million, 10 percent is used. Since the building cost for this option is $9,828,500, the estimated planning cost would be 10 percent of that, or $982,850.

Program Design--

Based on both an analysis of the likely requirements specific to Wisconsin, and the experience of other states, a cost of $100,000 was arrived at for the program design estimate.

Data Handling Software--

Based on discussions with computer systems analysts, an estimate of $200,000 was developed.

Personnel Training--

As indicated in Section 3, an initial, intensive training effort is required prior to program start up. Discussions with states and private contractors involved with I/M program operation, the personnel requirements for each facility was derived. The allocation of personnel are:

- One manager and one assistant manager per facility;
- Three inspectors per test lane for emission testing only;
- Four inspectors per test lane for combined emission, safety, and noise testing; and
- One maintenance person for every 10 lanes.

Applying these rates to the facility requirements developed previously, the basic operating personnel requirements for Option 1 are:

- 20 managers
- 20 assistant managers
- 344 inspectors
- 9 maintenance persons

The training cost per individual, as discussed in Section 3, are $53.00, $43,00, and $16.00, for instructors, investigators, and inspectors. Assuming that (1) the managers are to be trained as instructors, (2) assistant managers are to be trained at the inspector level, and (3) inspectors are to be trained at the inspector level, the total cost of training can be determined. This is computed as:

(20 manager)($53.00)+(20 assistant managers)($16.00)+(344 inspectors)($16.00)

= $6,884.00

Personnel Salaries--

Assuming (1) that all managerial personnel would be phased into the program 6 months prior to start-up; (2) inspectors would be phased into the program 1 month prior to start-up; and (3) the wage scale (a) for managers is $20,000 per year ($1,667.00 per month) (b) for assistant managers is $13,500 per year ($1,125.00 per month), (c) for maintenance personnel is $12,000 per year ($1,000.00 per month), and (d) for inspectors is $10,400 ($867.00 per month), (e) overhead is computed as 25 percent of the wage rate; a total personnel cost estimate for start-up can be derived. This is:

[(20 managers) ($1,667.00 per month) (6 months) +

(20 assistant managers) ($1,125 per month) (6 months) +

(9 maintenance persons) ($1,000.00 per month) (1 month) +

(344 inspectors ($867.00 per month) (1 month)] [1.25]

= $802,860.00

The administrative personnel costs must also be included in the start-up phase. These persons would be phased-in 18 months prior to start-up for this option. Based on the discussion of personnel requirements and salaries presented in Section 3, the costs associated with 18 months of start-up can be computed. These are shown in Table 30. The total personnel cost for start-up, then, is the total of the operational personnel and administrative personnel costs, or:

$802,860 + $756,375 = $1,559,235

Initial Public Information Program--

The cost estimate for this element was based on experience of various states and private contractors currently involved in operating I/M programs. The basic assumption is that a budget for initial public information should be apparently $0.12 per vehicle to be inspected, which translates to $213,000.

Annual Operating Costs

Facility Personnel--

Based on the facility staffing requirements and annual salaries associated with job category, the annual personnel costs can easily be computed. This estimate is shown in Table 31.

TABLE 30. ADMINISTRATIVE PERSONNEL COSTS ASSOCIATED WITH PROGRAM START-UP - OPTION 1

Job title	Number of positions	Annual salary per position	Total 18-month salaries for all positions
Administrator	1	$25,000	$ 37,500
Assistant Administrator (support)	1	17,000	25,500
Assistant Administrator (operations)	1	21,000	31,500
Legal Council	1	15,000	22,500
Purchasing Officer	1	13,000	19,500
Contracts Officer	1	13,000	19,500
Accountant	1	12,000	18,000
Engineer	1	10,400	15,600
Systems Analysts	1	11,000	16,500
Statistician/Programmer	1	10,500	15,750
Mechanic Training Coordinator	1	13,000	19,500
Regional Manager	3	21,500	96,750
Regional Inspector (licensing)	3	15,500	69,750
Regional Manager (surveillance)	3	15,500	69,750
Regional Public Information Coordinator	3	15,500	69,750
Mechanic Training Instructor	1	11,000	16,500
Instrument Repair Technician	1	12,000	18,000
Inspectors and Licensing Officers	1	15,500	23,250
Total salaries for 18 months			$605,100
Overhead @ 25 percent of salary			$151,275
Total Administrative personnel costs			$756,375

TABLE 31. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION 1

Job title	Total number of positions	Annual salary	Total annual salary for all positions
Manager	20	$ 20,000	$ 400,000
Assistant Manager	20	13,500	270,000
Maintenance Person	9	12,000	98,000
Inspectors	344	10,400	3,577,600
Total salaries			$4,345,600
Overhead @ 25 percent			$1,086,400
Total Annual Personnel Cost			$5,432,000

Maintenance--

Primary costs for maintenance reflect equipment repair, and preventive maintenance. In this connection, the yearly cost of these items was estimated to be 20 percent of the original cost. Specifically, this would be:

$$\$9,851,450 \times 0.20 = \$1,970,290.00$$

Utilities/Supplies/Services

Utilities--

Annual cost for utilities were derived from electric usages experienced by other states (Arizona). For Option 1 these were found to be: 166 kWh/day for each lane, plus 325 kWh/day per facility. Per kilowatt costs were obtained from Wisconsin Power and Light, and were found to be$0.05 kWh on average. The annual cost, then, for utilities is calculated below:

($86 lanes)(166 kWh/day)($0.05)(250 operating days per year)	=	$178,450
+ (20 facilities)(325 kWh/day)($0.05)(250 operating days per year)	=	81,250
Total utilities cost annually		$259,700

Insurance--

It is assumed that the operation would cover fire and theft as well as liability insurance. Based on previous experience (Arizona, HTS), insurance costs are generally about $1,500/lane. Annual costs based on this estimate are calculated below:

(86 lanes) ($1,500 per lane) = $129,000

Computer Operation--

Central computer operation costs for automated inspection systems have been estimated at $0.15 per test. This would compute to an annual cost of $225,000 for Option 1.

Inspection Forms--

In addition to the computer operation costs, a cost of $0.03 per test has been estimated based on previous experience (Arizona). This computes to a total annual cost of $45,000 for Option 1.

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating cost of the maintenance/calibration vans. The total annual calibration costs for Option 1 are outlined in Table 32, and was found to equal $79,200 annually.

TABLE 32. ANNUAL CALIBRATION COSTS FOR OPTION 1

Item	Cost ($)
Gases (20 sets per year @ $200 per set)	4,000
Maintenance on van	2,800
Insurance on van and equipment	1,000
Fuel, oil, etc.	1,000
Per calibration van	8,800
Vans	9
Annually	79,200

Taxes--

The cost for real estate and personal property taxes annually were calculated based on full value rates for each individual municipality,* and totals were found to be $623,356 for general property and $99,481 for real estate, equalling $722,837 for Option 1.

Uniforms--

Uniforms cost $125.00 per year annually, based on previous experience (Arizona). For Option 1 this translates to $49,125 annually for 393 uniformed employees.

The total annual cost for Utilities, Services and Supplies computed in Table 33, was found to be $1,509,862.

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*Town, Village, and City Taxes - 1976, Bulletin Nos. 176, 276, and 375, Wisconsin Department of Revenue.

TABLE 33. ANNUAL COST FOR UTILITIES, SERVICES, AND SUPPLIES

Utilities	$ 259,700
Insurance	129,000
Computer operation	225,000
Inspection forms	45,000
Calibration costs	79,200
Taxes	722,837
Uniforms	49,125
Total	$1,509,862

Annual Administrative Costs

Program Administrative --

Annual administrative personnel costs are computed from the personnel requirements and salaries, which were delineated previously. The annual cost computation is shown in Table 34.

Public Information--

The actual cost of public information can only be determined by state officials on an annual basis. For the purposes here, however, an estimate was developed based on other states experiences; this estimate is $180,000 annually.

Personnel Training--

This element reflects the ongoing requirement to train inspectors. The replacement rate (that is, the number of new inspectors to be trained annually) was estimated to be 10 percent of the inspector force, based on the experience of the Arizona program. Assuming an inspector work force of 344 (this will be derived later), the training (replacement) rate is 34, say 35, individuals per year. The cost for each individual trained is assumed to be approximately $16, therefore the entire cost is:

35 persons × $16/person = $560.00

Summary

The total cost of Option 1 is summarized in Tables 35 and 36.

FEE COMPUTATION

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors found in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars. For Option 1 this procedure is as follows:

Table 34. ANNUAL ADMINISTRATIVE PERSONNEL COSTS - OPTION 1

Job title	Number of positions	Annual salary per position ($)	Total annual salaries for all positions ($)
Administrator	1	25,000	25,000
Assistant Administrator (Support)	1	17,000	17,000
Assistant Administrator (Operations)	1	21,000	21,000
Legal Council	1	15,000	15,000
Purchasing Officer	1	13,000	13,000
Contractor Officer	1	13,000	13,000
Accountant	1	12,000	12,000
Engineer	1	10,400	10,400
Systems Analyst	1	11,000	11,000
Statistician/Programmer	1	10,500	10,500
Mechanic Training Coordinator	1	13,000	13,000
Regional Manager	3	21,500	64,500
Regional Inspector (Licensing)	3	15,500	46,500
Regional Manager (Surveillance)	3	15,500	46,500
Regional Public Information Coordiuator	3	15,500	46,500
Mechanic Training Instructor	1	11,000	11,000
Instrument Repair Technician	1	12,000	12,000
Inspectors and Licensing Officer	1	15,500	15,500
Total salaries			403,400
Overhead @ 25 percent			100,860
Total Annual Administrative Costs			504,250

Table 35. COST SUMMARY - OPTION 1

	Primary category		Principal element	Element cost ($)	Total category cost* ($)
I.	Initial capital costs	1.	Land investment	3,691,555	
		2.	Building investment	9,828,500	
		3.	Equipment costs	9,851,450	
					23,371,505
II.	One-Time Start-Up Costs	1.	Land acquisition	418,693	
		2.	Facilities planning	982,850	
		3.	Program design	100,000	
		4.	Development of data handling system hardware	200,000	
		5.	Personnel training	6,884	
		6.	Personnel salaries and overhead	1,559,235	
		7.	Initial public information program	213,000	
					3,480,662
III.	Annual Operating Costs	1.	Facility personnel	5,432,000	
		2.	Maintenance	1,970,290	
		3.	Utilities/services/supplies	1,509,862	
					8,912,152
IV.	Annual Administrative Costs	1.	Program administrative personnel salaries and overhead	504,250	
		2.	Public information	180,000	
		3.	Training	560	
					684,810

TABLE 36. ANNUALIZED COSTS FOR OPTION 1

When i = 0.03

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost (column 2)×(column 3)
I.	Capital Costs			
	1. Land	3,691,555	0.03	110,747
	2. Buildings	9,828,500	0.067	658,509
	3. Equipment	9,851,450	0.2184	2,151,557
II.	Start-Up Costs	3,480,662	0.2184	760,177
III.	Operating Costs			8,912,152
IV.	Administrative Costs			684,810
	Total			13,277,952

When i = 0.06

	Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost (column 2)×(column 3)
I.	Capital Costs			
	1. Land	3,690,555	0.06	221,493
	2. Buildings	9,828,500	0.087	855,080
	3. Equipment	9,851,450	0.2374	2,338,734
II.	Start-Up Costs	3,348,095	0.2374	826,309
III.	Operating Costs			8,912,152
IV.	Administrative Costs			684,810
	Total			13,838,578

To arrive at the uniform fee in constant dollars (f_c), the above total costs are divided by the number of paid inspections, 1,911,000. So, for $i = 0.03$

$$f_c = \frac{13,277,952}{1,911,000} = 6.95$$

and for $i = 0.06$

$$f_c = \frac{13,838,578}{1,911,000} = 7.24$$

To calculate a uniform fee in actual dollars (f_a) and expressed in 1978 dollars, we follow the above procedures using the appropriate amortization factors found in Section 3.

The uniform fee in actual dollars (f_a) and is expressed in a similar manner. For $i = 0.03$, $f_a = 8.74$, and $i = 0.06$, $f_a = 9.04$.

BENEFITS

The primary benefits associated with this option are in terms of emission reductions and potential safety improvements. The emission reduction beenfits described in Section 3 apply uniformly to all options, therefore there is no need to repeat the discussion here.

Benefits that accrue because of a safety inspection program are much more difficult to quantify than are emission benefits. Whereas the safety program is still in a preliminary, conceptual stage, it may not be appropriate to attempt a quantitative analysis at this point.

The intent of motor vehicle safety programs is to reduce accident potential by taking steps to ensure that motor vehicles are maintained at least to minimum standards with regard to safety-related system and components. Very strong arguments have been made both for and against the need for periodic safety inspection programs. One of the difficulties in assessing the potential benefits of safety programs is the lack of definitive studies of the effectiveness of these programs in reducing actual accidents. Many studies have been conducted that attempt to assign causes to accidents and these have generall indicated that a relatively small percentage - about 5 to 7 percent - of all accidents are a direct result of vehicle system or component failures or defects. However, these studies also indicate that vehicle system defects are thought to be a contributing factor in up to about 24 percent of all accidents. These types of statistics have often been used to support arguments either for or against the need for inspection programs. Yet, upon closer consideration it becomes clear that statistics regarding causal aspects of accidents are not performance indicators of safety inspection programs. One can make a general inference that safety inspections have the potential for reducing accidents provided that the inspection program is, in fact, able to reduce the number of safety defects found in in-use vehicles. For most individuals, the primary benefit of the safety inspection program will essentially be the opportunity of having their vehicle inspected and being made aware of any safety-related deficiencies.

When i = 0.03

TABLE 36 (continued).

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost (column 2)×(column 3)
I.	Capital Cost			
	1. Land	3,691,555	0.10	369,155
	2. Buildings	9,828,500	0.117	1,149,934
	3. Equipment	9,851,450	0.264	2,600,782
II.	Start-Up Costs	3,480,662	0.264	918,895
III.	Operating Costs	8,912,152	1.215	10,828,265
IV.	Administrative Costs	684,810	1.215	832,044
	Total			16,699,075

When i = 0.06

	Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost (column 2)×(column 3)
I.	Capital cost			
	1. Land	3,691,555	0.13	479,902
	2. Buildings	9,828,500	0.142	1,395,647
	3. Equipment	9,851,450	0.284	2,797,811
II.	Start-Up Costs	3,480,662	0.284	988,508
III.	Operating Costs	8,912,152	1.210	10,783,704
IV.	Administrative Costs	684,810	1.210	828,620
	Total	16,699,075		17,274,192

Then, if $i = 0.03$, $f_a = \frac{16,699,075}{1,911,000} = 8.74$; and if $i = 0.06$, $f_a = \frac{17,274,192}{1,911,000} = 9.04$

ADDITIONAL DISCUSSION ON THE SAFETY INSPECTION ELEMENT

Two additional points should be made regarding safety inspections. The first concerns the definition of what constitutes either a failure or a deficiency, particularly with regard to what affect the interpretation has on whether a vehicle must be reinspected or not. Experience has shown, for instance, that the use of a photocell headlight aiming device will result in identifying many deficiencies in headlight aim since, in most instances, headlight adjustments are made in a very unprecise manner. The question, then, concerns whether or not (for instance) a vehicle whose headlights are found to be out fo adjustments according to the photocell device should be considered to have failed the inspection and, therefore, require a reinspection after the proper adjustments have been made. This will obviously have a large impact on the population of vehicles to be tested.

Another question that arises (again, using the headlight aiming problem as an example) is whether or not adjustments of any deficiencies should be attempted during inspection. If a headlight adjustment were made, it would require only a few minutes, but considering the very short throughput time used in calculating station requirements, even these relatively quick adjustments could overload the facility from time to time.

A third question related to the discussion thus far concerns the ability of the automobile repair industry to actually perform repairs to the standards measured by several of the inspection devices, unless the repair facilities are equipped with similar pieces of equipment. If the repair industry cannot utilize the diagnostic information provided from the use of a device such as a photocell headlight aiming device, then the merit of using the device is questionable.

Expansion of the Safety Program to the Rest of the State

The following analysis of expanding the safety program to cover the entire state is offered.

Discussion--

Given the 1977 registrations of LDV's and LDC's in the 63 counties (excluding the counties previously studied) = 1,242,761. Assuming a steady 3 percent growth rate in the vehicle population, there will be approximately 1,670,000 registrations in this area in 1987.

Assume that no motorist need drive over 5 miles to an inspection garage. Then the total service area per station = $\pi (5)^2 = 78.54\ m^2$. Then, in order to completely cover this rural area, $\frac{50,120}{78.54} = 638$ garages are needed.

Assuming that the number of garages in 1987 is 60 percent of 1972 totals, there will be (8627)(0.6) = 5,176 garages in the entire state in 1987. Subtracting out the nine urban counties, leaves 5,176 - 1,973 = 3,203 rural garages. Given the 5-mile service area radius, a participation rate of $\frac{638}{3,203} = 20$ percent of private garages will be needed, and each garage should have a daily throughput of $\frac{1,670,000}{(638)(250\ \text{days/yr})} = 10.5$ cars/day.

Assuming that the private garages need not make any additional investment in capital or labor to become an inspection station, but rather merely pay a licensing fee to the state, costs to a garage will be minimal, and the above participation will be easily attained. Costs to the state will be restricted to cars and salaries for private garage licensing and inspection officials. If one inspector can visit 70 garages per month, then a maximum of 10 or 15 inspectors would be needed to make monthly visits to each garage, safety spot checks, etc. These inspectors would need only small cars rather than the expensive calibration vans needed for the urban network. Then state expenses would be (assuming one inspector car = \$4,500 and his salary = \$10,000/yr), \$145,000 to \$217,500. If each garage pays an annual licensing fee of \$100.00, the state would have to charge from \$145,000 to \$63,800 = $\frac{\$\ 81,200}{1,670,000}$ = \$0.05. to \$217,500 to \$63,800 = $\frac{\$\ 153,700}{1,670,000}$ = \$0.09 per inspection, depending on the number of inspectors hired.

SECTION 5

OPTION 2 - CENTRALIZED, CONTRACTOR-OPERATED LOADED MODE EMISSIONS INSPECTION ONLY

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized emission inspection stations throughout the nine-county area defined in Section 2. The emission inspection would be a loaded-mode test, and would involve all light-duty gasoline-powered vehicles under 13 years old, on an annual basis.

The vehicle population to be tested in this option is the same as that described in the discussion of Option 1. Due to the fact that safety and noise inspection tasks are not required by this option, the throughput time per vehicle inspected is assumed to be two minutes. If a work week of 48 hours and an efficiency factor of 0.67 are assumed, the number of vehicles that can be inspected by one lane per year is:

(30 vehicles/hour) (48 hours/week) (52 weeks/year) (0.67) = 50,170

Dividing the number of inspections to be performed by this per-lane annual throughput figure yields the number of inspection lanes required in each county. These lane requirements are shown in Table 37.

TABLE 37. TOTAL INSPECTION LANES REQUIRED TO SATISFY 1990 INSPECTION DEMAND

County	Numbers of Lanes Required
Brown	4
Dane	6
Kenosha	3
Milwaukee	18
Ozaukee	2
Racine	4
Walworth	2
Washington	2
Waukesha	6
Total	47

Using the same approach for facility allocation and siting in each of the counties as that described for Option 1, a 15 facility network was derived, with station locations and configurations as shown in Table 38.

OPTION COSTS

The costs associated with the implementation of this option are presented below. Reference should be made to the discussion in Section 3 concerning the analytical techniques used.

Capital Costs

Buildings--

As indicated in the discussion of Option 1, a building cost of $25.00 per square foot was assumed for all the centralized options. For this option, an analysis of the specific inspection tasks to be performed, including dimensions of equipment required, was made to define the general features that would be included in an inspection facility. A conceptual floor plan for a basic one-lane facility for loaded emissions inspection is shown in Figure 4. Multi-lane facilities would require roughly the inspection area shown times the number of lanes, although some additional space would be required for waiting and rest areas. Table 39 shows the building area requirements of facility configurations ranging from 1 to 6 lanes.

TABLE 39. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS - OPTION 2

Configuration	Floor Area Required (ft^2)						
	Test Area	Administration	Employee Rest	Storage	Wait	Rest Rooms	Total
1 lane	1,800	1,000	300	325	570	85	4,080
2 lane	3,600	1,000	350	350	930	85	6,315
3 lane	5,400	1,000	400	380	1,530	85	8,795
4 lane	7,200	1,000	440	410	2,370	85	11,505
5 lane	9,000	1,000	485	435	3,450	85	14,555
6 lane	10,800	1,000	525	465	4,770	85	17,645

Taking $25.00 as a unit building cost per square foot, the actual cost estimates for network facilities can be computed for this option, and are shown in Table 40.

Land Costs--

The primary determinants of land cost for any option are the unit cost per square foot and the total size (in square feet) of the land to be acquired. In Section 3, the unit cost estimates for land in each county were presented, and these estimates will be used here.

TABLE 38. INSPECTION NETWORK REQUIREMENTS FOR OPTION 2

County	Town	Number of Facilities	Configuration
Brown	Green Bay	1	2 lanes
	Bellevue	1	2 lanes
Dane	Madison	1	3 lanes
	Suburbs	1	3 lanes
Kenosha	Kenosha	1	3 lanes
Milwaukee	Milwaukee	3	5 lanes
	Greenfield	1	3 lanes
Ozaukee	Cedarburg	1	2 lanes
Racine	Racine	1	4 lanes
Walworth	Elkhorn	1	2 lanes
Washington	West Bend	1	2 lanes
Waukesha	Brookfield	1	3 lanes
	Waukesha	1	3 lanes
Total Network		15 facilities	47 lanes

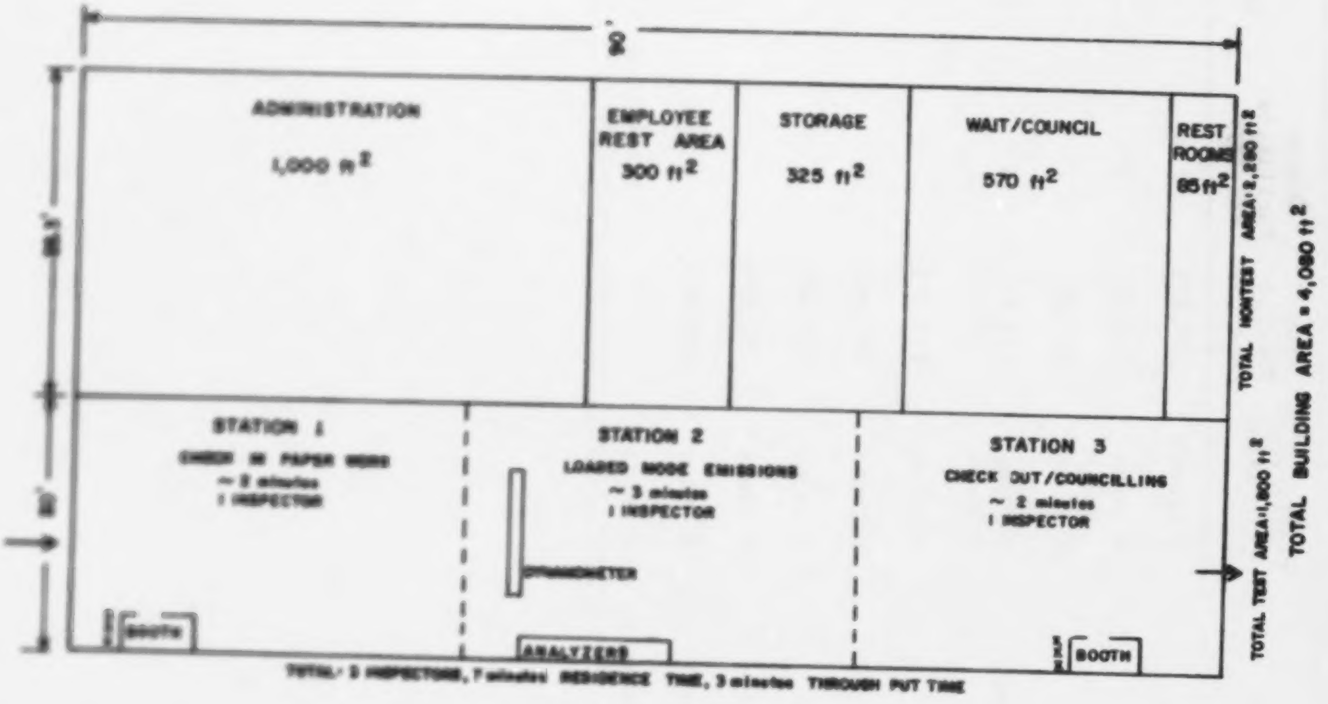
90'
25.3'
20'
ADMINISTRATION
1,000 ft²
EMPLOYEE REST AREA
300 ft²
STORAGE
325 ft²
WAIT/COUNCIL
570 ft²
REST ROOMS
85 ft²
TOTAL NONTEST AREA: 2,280 ft²
STATION 1
CHECK IN PAPER WORK
~ 2 minutes
1 INSPECTOR
STATION 2
LOADED MODE EMISSIONS
~ 3 minutes
1 INSPECTOR
DYNAMOMETER
ANALYZERS
STATION 3
CHECK OUT/COUNCILLING
~ 2 minutes
1 INSPECTOR
BOOTH
BOOTH
TOTAL TEST AREA: 1,800 ft²
TOTAL BUILDING AREA = 4,080 ft²
TOTAL: 3 INSPECTORS, 7 minutes RESIDENCE TIME, 3 minutes THROUGH PUT TIME

Figure 4. Conceptual floor plan for a loaded-mode emission inspection facility.

TABLE 40. BUILDING COST ESTIMATES FOR OPTION 2

County	Facility Configuration	Per Facility Cost ($)	Number Facilities Required	Total Cost ($)
Brown	2 lanes	157,875	2	315,750
Dane	3 lanes	219,875	2	439,750
Kenosha	3 lanes	219,875	1	219,875
Milwaukee	5 lanes	363,875	3	1,091,625
	3 lanes	219,875	1	219,875
Ozaukee	2 lanes	157,875	1	157,875
Racine	4 lanes	287,625	1	287,625
Walworth	2 lanes	157,875	1	157,875
Washington	2 lanes	157,875	1	157,875
Waukesha	3 lanes	219,875	2	439,750
Total Network	47 lanes		15 Facilities	$3,487,875

Lot size requirements are a function of facility size (i.e., the number of inspection lanes). As in Option 1, we will define the land to building ratio as 5:1. Thus, for each facility in the network, raw land costs can be calculated, and are shown in Table 41.

Adding the land improvement costs to the raw land costs listed above yields the total land investment. Standard paving and landscaping formulas, used in the Option 1 analysis, were applied to the lot requirements for this option; Table 42 lists Total Area, Paved Area, and Landscaped Area for each facility configuration.

TABLE 42. PAVEMENT AND LANDSCAPING REQUIREMENTS FOR OPTION 2 FACILITIES, ft^2

Facility Configuration	Total Area	Paved Area	Landscaped Area
1 lane	20,400	6,485	9,835
2 lane	31,575	13,105	12,155
3 lane	43,975	19,320	15,860
4 lane	57,520	25,620	20,346
5 lane	72,275	32,020	25,800
6 lane	88,225	38,235	32,345

The same per square foot costs for paving and landscaping used in Option 1 are assumed. The improvement costs for each facility type are shown in Table 43.

TABLE 43. LAND IMPROVEMENT COSTS FOR INSPECTION SITES UNDER OPTION 2

Facility Configuration	Pavement Costs	Landscaping Cost	Total Improvement Cost
1 lane	$5,188	$2,459	$7,647
2 lanes	10,484	3,039	13,523
3 lanes	15,456	3,965	19,421
4 lanes	20,536	5,087	25,623
5 lanes	25,616	6,450	32,066
6 lanes	30,588	8,086	38,674

Land improvement costs can then be calculated for the entire option 2 network, are shown in Table 44. The total land investment, then, is $1,006,547 + 305,962 = $1,312,509.

TABLE 41. LAND COSTS FOR EACH INSPECTION FACILITY IN OPTION 2

County	Municipality	Facility configuration	Number of facilities	Total building Area (ft^2)	Land area (ft^2)	Unit cost of land ($/sq ft)	Total land cost ($)
Brown	Green Bay	2 lanes	1	6,315	31,575	1.70	53,678
	Bellevue	2 lanes	1	6,315	31,575	1.00	31,575
Dane	Madison	3 lanes	1	8,795	43,975	2.00	87,950
	Suburbs	3 lanes	1	8,795	43,975	1.00	43,975
Kenosha	Kenosha	3 lanes	1	8,795	43,975	1.70	74,758
Milwaukee	Milwaukee	5 lanes	3	43,665	218,325	1.50	327,488
	Greenfield	3 lanes	1	8,795	43,975	1.50	65,963
Ozaukee	Cedarburg	2 lanes	1	6,315	31,575	0.60	18,945
Racine	Racine	4 lanes	1	11,505	57,520	0.75	43,140
Walworth	Elkhorn	2 lanes	1	6,315	31,575	0.67	21,155
Washington	West Bend	2 lanes	1	6,315	31,575	0.85	26,839
Waukesha	Brookfield	3 lanes	1	8,795	43,975	2.50	109,938
	Waukesha	3 lanes	1	8,795	43,975	2.30	101,143
Total		47 lanes	15				1,006,547

TABLE 44. LAND IMPROVEMENT COSTS FOR FACILITIES UNDER OPTION 2

County	Municipality	Facility Configuration	Number of Facilities	Cost Per Facility	Total Improvement Cost
Brown	Green Bay	2 lanes	1	$13,523	$13,523
	Bellevue	2 lanes	1	13,523	13,523
Dane	Madison	3 lanes	1	19,421	19,421
	Suburbs	3 lanes	1	19,421	19,421
Kenosha	Kenosha	3 lanes	1	19,421	19,421
Milwaukee	Milwaukee	5 lanes	3	32,066	96,198
	Greenfield	3 lanes	1	19,421	19,421
Ozaukee	Cedarburg	2 lanes	1	13,523	13,523
Racine	Racine	4 lanes	1	25,623	25,623
Walworth	Elkhorn	2 lanes	1	13,523	13,523
Washington	West Bend	2 lanes	1	13,523	13,523
Waukesha	Brookfield	3 lanes	1	19,421	19,421
	Waukesha	3 lanes	1	19,421	19,421
Total					$305,962

Equipment Costs--

The equipment items required to operate a loaded-mode emissions inspection facility were identified through consultations with equipment manufacturers and state and local officials. For this option, the equipment required are a chassis dynamoter and an emission analyzer as costed in Tables 45 and 46.

As in Option 1, the costs of calibration vans and associated equipment and a central computer should be included in total equipment costs. For this option five calibration vans will be required, each estimated at $14,000. The central computer will be the same as described in Option 1, and will cost approximately $250,000. The total equipment investment for Option 2 then is the sum of facility test equipment, calibration vans and central computer as:

$$\$3,385,500 + \$70,000 + \$250,000 = \$3,705,500$$

One-Time Startup Costs

Land Acquisition--

As explained in Section 3, the cost of site location and evaluation, surveying, price negotiation and title conveyance are assumed to be $6,000 per site plus 10 percent of the purchase price to cover the costs associated with purchasing the land.

For this option, a total of 15 facilities are required reflecting a total land investment (unimproved) of 1,006,547. The aquisition cost, then, is:

$$(15\ \text{facilities})\ (6{,}000/\text{facility}) + (0.10)\ (1{,}006{,}547) = 190{,}655$$

Facilities Planning--

This element is computed in the same manner as for Option 1. For building investments of $3 million to $6 million, 15 percent of the construction cost is used. The building cost of this option is $3,487,875, so the estimated planning cost would be 15 percent of that or $523,181.

Program Design--

As explained for Option 1, a cost of $100,000 was used.

Data Handling Systems--

The cost of development of data handling software are assumed to be the same as those for Option 1, $200,000.

Personnel Training--

The numbers of personnel to be trained are as follows for Option 2:

- 15 managers
- 15 assistant managers
- 141 inspectors
- 5 maintenance persons

TABLE 45. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR OPTION 2

Number of Lanes	Equipment Cost
1	$126,500
2	173,000
3	219,500
4	266,000
5	312,500
6	359,000

TABLE 46. EQUIPMENT COSTS FOR OPTION 2

County	Munici-pality	Facility configuration	Number of facilities required	Equipment cost per facility	Total cost of equipment
Brown	Green Bay	2 lanes	1	$173,000	$173,000
	Bellevue	2 lanes	1	173,000	173,000
Dane	Madison	3 lanes	1	219,500	219,500
	Suburbs	3 lanes	1	219,500	219,500
Kenosha	Kenosha	3 lanes	1	219,500	219,500
Milwaukee	Milwaukee	5 lanes	3	312,500	937,500
	Greenfield	3 lanes	1	219,500	219,500
Ozaukee	Cedarburg	2 lanes	1	173,000	173,000
Racine	Racine	4 lanes	1	266,000	266,000
Walworth	Elkhorn	2 lanes	1	173,000	173,000
Washington	West Bend	2 lanes	1	173,000	173,000
Waukesha	Brookfield	3 lanes	1	219,500	219,500
	Waukesha	3 lanes	1	219,500	219,500
Total					3,385,500

The training costs for these individuals are as discussed in Section 3: $53.00, $43.00 and $16.00 for instructors, investigators, and inspectors, respectively. Using the same assumptions for training as in Option 1, training costs for Option 3 are as follows:

(15 managers)($53.00) + (15 assistant managers)($16.00)
+ (146 inspectors and maintenance persons)($16.00) = $3,371

Personnel Salaries--

The same assumptions for startup personnel requirements for Option 1 were used. Substituting the personnel numbers for Option 2, the cost of test personnel for the startup period is calculated below:

[(15 managers)($16666.67/month)(6 months) + (15 asst. managers)($1125/month) (6 months) + (5 maintenance/calib.)($1000/month)(1 month) + (141 inspectors) ($866.67/month)(1 month)] x [1.25] = $473,063.

The administrative personnel costs for the startup phase will be the same as for Option 1, Table 29, or $756,375.

The total personnel cost for startup then is the sum of the above two figures, or

$473,063 + $756,375 = $1,229,438

Initial Public Information Program--

As explained in Option 1, the cost for initial startup of a public relations campaign would be approximately $0.12 per vehicle inspected, or $213.000.

Annual Operating Costs

Based on the facility staffing requirements and annual salaries previously discussed, the annual personnel costs can easily be computed. These costs are shown in Table 47.

TABLE 47. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION 2

Job Title	Total Number of Positions	Annual Salary	Total Annual Salary for all Positions
Manager	15	$20,000	$300,000
Assistant manager	15	13,500	270,000
Maintenance person	5	12,000	60,000
Inspectors	141	10,400	$1,466,400
	Total Salaries		$2,028,900
	Overhead @ 25%		507,225
			$2,536,125

Maintenance--
Primary costs for maintenance in this option reflect equipment repair and preventive maintenance. The annual cost of these functions is estimated to be 20 percent of the original test equipment cost, or:

($3,385,500)(0.20) = $677,100

Utilities, Services, and Supplies

Utilities--
Annual costs for utilities were derived from electric usage experienced by similar facilities in other states (Arizona). For Option 2, these were found to be 120 kWh per day per land plus 325 kWh per day per facility. Assuming the same cost per kWh as in previous options, the annual cost for all facilities is calculated below:

47 lanes @ 120 kWh/day x $0.05 per hour x 250 days = $ 70,500

15 facilities @ 325 kWh/day x $0.05 per hour x 250 days = $ 60,938

Total utility costs per year = $131,438

Insurance--
Based on the $1,500 per lane insurance costs assumed for Option 1, total annual insurance costs for Option 2 will be:

$1,500 x 47 = $70,500

Computer Operation--
Central computer operation costs for automated inspection systems have been estimated at $0.15 per test, or $225,000, as in Option 1.

Inspection Forms--
Using the $0.03 per inspection assumption as under Option 1, the inspection form printing and distribution costs will be $45,000 per year.

Calibration Costs--
The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating costs of maintenance/calibration vans. Using the $8,800 annual cost per van derived in the discussion of Option 1, calibration costs will be:

$8,800 x 5 = $44,000

Taxes--
The annual cost for real estate and personal property taxes were calculated based on full valuation rates for each municipality in which stations are to be located. Total taxes were found to be:

General Propery Tax	$189,293
Real Estate Tax	31,812
Total	$221,105

Uniforms--

Based on the assumption of $125.00 annual uniform costs, and a total of 176 uniformed employees, a total annual uniform costs of $22,000 will be experienced in Option 2.

The total annual cost of utilities, services, and supplies is shown in Table 48.

TABLE 48. ANNUAL COST OF UTILITIES, SERVICES AND SUPPLIES

Utilities	$131,438
Insurance	70,500
Computer operation	225,000
Inspection forms	45,000
Calibration costs	44,000
Taxes	221,105
Uniforms	22,000
Total	759,000

Annual Administrative Costs

Program Administrative Personnel--

Annual administrative personnel costs are the same for Option 2 as for Option 1. From Table 31 these are found to be $504,250 annually.

Public Information--

The annual cost for public information for Option 2 was assumed the same as previously stated for Option 1, $180,000.

Personnel Training--

Using the same assumptions as for Option 1, an annual turnover of 10 percent, or 14 employees, can be expected. This relates to an annual cost of $224 based on a $16 per inspection charge.

SUMMARY

The total cost of Option 2 is summarized in Table 49.

Initial capital costs and one-time startup costs are converted to annual figures using the amortization factors found in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars. For Option 2 this procedure is as follows:

TABLE 49. COST SUMMARY - OPTION 2

	Primary category	Principal element	Element cost ($)	Total category cost ($)
I.	Initial capital costs	Land investment	$1,312,509	
		Building investment	3,487,875	
		Equipment costs	3,705,500	
				$8,505,884
II.	One-time startup costs	Land acquisition	190,655	
		Facilities planning	523,181	
		Program design	100,000	
		Development of data handling system software	200,000	
		Personnel training	3,371	
		Personnel salaries and overhead	1,229,438	
		Initial public information program	213,000	
				$2,459,645
III.	Annual operating costs	Facility personnel	2,536,125	
		Maintenance	667,100	
		Utilities/Supplies/Services	759,043	
				$3,962,268
IV.	Annual administrative costs	Program administrative salaries	504,250	
		Public information	180,000	
		Training	224	
				$ 684,474

fc
When i = 0.03

	Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost (column 2)×(column 3)
I.	Capital costs			
	1. Land	1,312,509	0.03	39,375
	2. Buildings	3,487,875	0.067	233,688
	3. Equipment	3,705,500	0.2184	809,281
II.	Startup costs	2,459,645	0.2184	537,186
III.	Operating costs	3,962,268	1.0	3,962,268
IV.	Administrative costs	684,744	1.0	684,474
	Total			6,266,542

$fc_{0.03}$ cost per inspection = 6,266,542/1,911,000 = 3.28

fc
When i = 0.06

	Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost (column 2)×(column 3)
I.	Capital costs			
	1. Land	1,312,509	0.06	78,751
	2. Buildings	3,487,875	0.087	303,445
	3. Equipment	3,705,500	0.2374	879,686
II.	Startup costs	2,459,645	0.2374	583,920
III.	Operating costs	3,962,268	1.0	3,962,268
IV.	Administrative costs	684,744	1.0	684,474
	Total			6,492,814

$fc_{0.06}$ cost per inspection = 6,492,814/1,911,000 =3.40

fa
When $i = 0.03$

	Cost class	Cost ($)	Amortization factor for $i = 0.03$	Annualized cost (column 2)×(column 3)
I.	Capital costs			
	1. Land	1,312,504	0.10	131,251
	2. Buildings	3,487,875	0.117	408,081
	3. Equipment	3,705,500	0.264	978,252
II.	Startup costs	2,459,645	0.264	649,346
III.	Operating costs	3,962,268	1.215	4,814,156
IV.	Administrative costs	684,744	1.215	831,964
	Total			7,813,050

$fa_{0.03}$ cost per inspection = 7,813,050/1,911,000 = 4.09

fa
When $i = 0.06$

	Cost class	Cost ($)	Amortization factor for $i = 0.06$	Annualized cost (column 2)×(column 3)
I.	Capital costs			
	1. Land	1,312,509	0.13	170,626
	2. Buildings	3,487,875	0.142	495,278
	3. Equipment	3,705,500	0.284	1,052,362
II.	Startup costs	2,459,645	0.284	698,539
III.	Operating costs	3,962,268	1.210	4,794,344
IV.	Administrative costs	684,744	1.210	828,540
	Total			8,003,689

$fa_{0.06}$ cost per inspection = 8,003,689/1,911,000 = 4.19

SECTION 6

OPTION 3 - CENTRALIZED, CONTRACTOR-OPERATED, IDLE MODE EMISSIONS TEST

OPTION DEFINITION

This option involves a private contractor establishing a network of centralized emissions inspection stations throughout the 9-county area defined in Section 2. The emissions inspection would be an idle-mode test, and would be required of all light-duty gasoline-powered vehicles under 13 years old on an annual basis.

NETWORK REQUIREMENTS

The vehicle population to be tested in this option is the same as that described in the discussion of Option 1. Detailed consultations with both equipment manufacturers and state and local officials have led us to conclude that a reasonable estimate for per-vehicle throughput time for an idle mode inspection is 2 minutes. If the previous 48-hour work week and 0.67 efficiency factor are still assumed, the number of vehicles that can be inspected by one lane per year is:

$$(30 \text{ cars/hour})(48 \text{ hours/week})(52 \text{ weeks/year})(0.67) = 50{,}170 \text{ vehicles}$$

Dividing the number of inspections to be performed by this per-lane annual throughput figure yields the number of inspection lanes required in each county. These lane requirements are shown in Table 50.

TABLE 50. TOTAL INSPECTION LANES REQUIRED TO MEET 1990 INSPECTION DEMAND

County	Number of lanes required
Brown	4
Dane	6
Kenosha	3
Milwaukee	18
Ozaukee	2
Racine	4
Walworth	2
Washington	2
Waukesha	6
Total	47

Using the same approach for facility allocation and siting in each of the counties as that described for Option 1, a 15-facility network was derived, with station locations and configurations as shown in Table 51.

TABLE 51. INSPECTION NETWORK REQUIREMENTS FOR OPTION 3

County	Town	Number of facilities	Configuration
Brown	Green Bay	1	2 lanes
	Bellevue	1	2 lanes
Dane	Madison	1	3 lanes
	Suburbs	1	3 lanes
Kenosha	Kenosha	1	3 lanes
Milwaukee	Milwaukee	3	5 lanes
	Greenfield	1	3 lanes
Ozaukee	Cedarburg	1	2 lanes
Racine	Racine	1	4 lanes
Walworth	Elkhorn	1	2 lanes
Washington	West Bend	1	2 lanes
Waukesha	Brookfield	1	3 lanes
	Waukesha	1	3 lanes
Total network		15 facilities	47 lanes

OPTION COSTS

The costs associated with the implementation of this option are presented below. Reference should be made to the discussion in Section 3 concerning the analytical techniques used.

Capital Costs

Buildings--

As indicated in the discussion of Option 1, a building cost of $25.00 per square foot was assumed for all the centralized facility options. For this option, an analysis of the specific tasks required for idle mode inspection, including dimensions of equipment required, was made to define the general features that would be included in an inspection facility. A conceptual floor plan for a basic one-lane facility for idle mode inspection is shown in Figure 5. Multi-lane facilities would require roughly the inspection area shown times the number of lanes, although some additional space would be

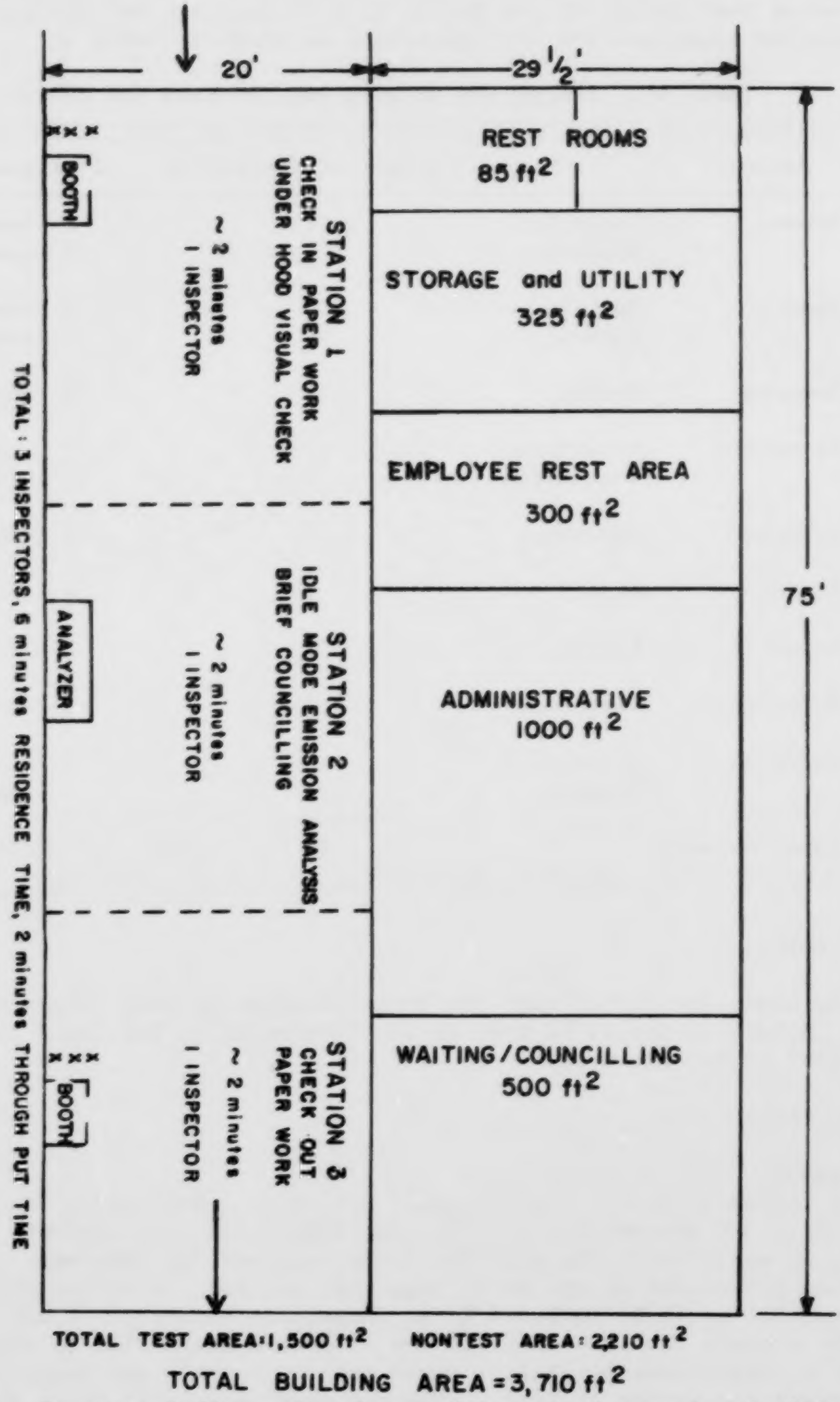
20'
29 1/2'
75'
REST ROOMS 85 ft²
STORAGE and UTILITY 325 ft²
EMPLOYEE REST AREA 300 ft²
ADMINISTRATIVE 1000 ft²
WAITING/COUNCILLING 500 ft²
STATION 1 CHECK IN PAPER WORK UNDER HOOD VISUAL CHECK
~ 2 minutes 1 INSPECTOR
BOOTH
STATION 2 IDLE MODE EMISSION ANALYSIS BRIEF COUNCILLING
~ 2 minutes 1 INSPECTOR
ANALYZER
STATION 3 CHECK OUT PAPER WORK
~ 2 minutes 1 INSPECTOR
BOOTH
TOTAL: 3 INSPECTORS, 6 minutes RESIDENCE TIME, 2 minutes THROUGH PUT TIME
TOTAL TEST AREA: 1,500 ft²
NONTEST AREA: 2,210 ft²
TOTAL BUILDING AREA = 3,710 ft²

Figure 5. Conceptual floor plan for an idle mode inspection facility.

required for waiting and rest areas, etc. Table 52 shows the building area requirements of facility configurations ranging from one to six lanes.

Taking $25.00 as a unit building cost per square foot, the actual cost estimates for network facilities can be computed for this option, and are shown in Table 53.

Land Costs--

The primary determinants of land cost for any option are the unit cost per square foot and the total size (in square feet) of the land to be acquired. In Section 3, the unit cost estimates for land in each county were presented, and these estimates will be used here.

Lot size requirements are a function of facility size (i.e., the number of inspection lanes). As in Option 1, we will define the land:building ratio as 5:1. Thus, for each facility in the network, raw land costs can be calculated, and are shown in Table 54.

Adding the land improvement costs to the raw land costs listed above yields the total land investment. Standard paving and landscaping formulas, used in the Option 1 analysis, were applied to the lot requirements for this option; Table 55 lists Total Area, Paved Area, and Landscaped Area for each facility configuration.

The same costs per square foot used in Option 1 are assured. The improvement costs for each type of facility are shown in Table 56.

Land improvements cost can then be calculated for the entire Option 3 network, as shown in Table 57. The total land investment, then, is $890,481 + $283,840 = $1,174,321.

Equipment Costs--

The equipment items required to operate a loaded-mode emissions inspection facility were identified through consultations with equipment manufacturers and state and local officials. For this option, the eqiipment required is an automated CO/HC analyzer which costs $21,500. When added to computer facilities and miscellaneous tools, the total equipment investment as a function of facility configuration is shown in Table 58.

The total cost for equipment in the Option 3 network can be computed based on the number of facilities by configuration developed previously. These costs are shown in Table 59.

One-time Startup Costs

Land Acquisition--

As before, the cost of land acquisition is assumed to be $6,000 per site plus 10 percent of the purchase price. For this option a total of 15 sites are required. The total unimproved land investment being $890,481, the acquisition cost is:

TABLE 52. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS - OPTION 3

Configuration	Floor area required (ft^2)						
	Test area	Administration	Employee rest	Storage	Waiting	Restrooms	Total
1 lane	1,500 ft^2	1,000 ft^2	300 ft^2	325 ft^2	500 ft^2	85 ft^2	3,710 ft^2
2 lane	3,000	1,000	330	350	850	85	5,615
3 lane	4,500	1,000	375	375	1,450	85	7,785
4 lane	6,000	1,000	400	400	2,300	85	10,185
5 lane	7,500	1,000	450	425	3,375	85	12,835
6 lane	9,000	1,000	480	425	4,700	85	15,690

TABLE 53. BUILDING COST ESTIMATES FOR OPTION 3

County	Facility configuration	Per facility cost	Number of facilities required	Total cost
Brown	2 lane	$140,375	2	$ 280,750
Dane	3 lane	194,625	2	389,250
Kenosha	3 lane	194,625	1	194,625
Milwaukee	5 lane	320,875	3	962,625
	3 lane	194,625	1	194,625
Ozaukee	2 lane	140,375	1	140,375
Racine	4 lane	254,625	1	254,625
Walworth	2 lane	140,375	1	140,375
Washington	2 lane	140,375	1	140,375
Waukesha	3 lane	194,625	2	389,250
Total network-47 lanes			15 facilities	$3,086,875

TABLE 54. LAND COSTS FOR EACH INSPECTION FACILITY IN OPTION 3

County	Municipality	Facility configuration	Number of facilities	Total building area (ft^2)	Land area (ft^2)	Unit cost of land/ft^2	Total land
Brown	Green Bay	2 lane	1	5,615	28,075	$1.70	$ 47,728
	Bellevue	2 lane	1	5,615	28,075	$1.00	$ 28,075
Dane	Madison	3 lane	1	7,785	38,925	$2.00	$ 77,850
	Suburbs	3 lane	1	7,785	38,925	$1.00	$ 38,925
Kenosha	Kenosha	3 lane	1	7,785	38,925	$1.70	$ 66,173
Milwaukee	Milwaukee	5 lane	3	38,505	192,525	$1.50	$288,788
	Greenfield	3 lane	1	7,785	38,925	$1.50	$ 58,388
Ozaukee	Cedarburg	2 lane	1	5,615	28,075	$0.60	$ 16,845
Racine	Racine	4 lane	1	10,185	50,925	$0.75	$ 38,194
Walworth	Elkhorn	2 lane	1	5,615	28,075	$0.67	$ 18,810
Washington	West Bend	2 lane	1	5,615	28,075	$0.85	23,864
Waukesha	Brookfield	3 lane	1	7,785	38,925	$2.50	$ 97,313
	Waukesha	3 lane	1	7,785	38,925	$2.30	$ 89,528
Totals		47 lanes	15	123,475	617,375		$890,481

TABLE 55. PAVEMENT AND LANDSCAPING REQUIREMENTS FOR OPTION 3 FACILITIES, ft^2

Facility configuration	Total area	Paved area	Landscaped area
1 lane	18,550	6,215	8,625
2 lane	28,075	12,430	10,030
3 lane	38,925	18,645	12,495
4 lane	50,925	24,725	16,015
5 lane	64,175	30,940	20,400
6 lane	78,450	37,020	25,740

TABLE 56. LAND IMPROVEMENT COSTS FOR INSPECTION FACILITY SITES UNDER OPTION 3

Facility configuration	Pavement costs	Landscaping costs	Total improvement costs
1 lane	$ 4,972	$2,156	$ 7,128
2 lane	$ 9,944	$2,508	$12,452
3 lane	$14,916	$3,124	$18,040
4 lane	$19,780	$4,004	$23,784
5 lane	$24,752	$5,100	$29,852
6 lane	$29,616	$6,435	$36,051

TABLE 57. LAND IMPROVEMENT COSTS FOR FACILITIES UNDER OPTION 3

County	Municipality	Facility configuration	Number of facilities	Cost per facility	Total improvements
Brown	Green Bay	2 lane	1	$12,452	$ 12,452
	Bellevue	2 lane	1	12,452	12,452
Dane	Madison	3 lane	1	18,040	18,040
	Suburbs	3 lane	1	18,040	18,040
Kenosha	Kenosha	3 lane	1	18,040	18,040
Milwaukee	Milwaukee	5 lane	3	29,852	89,556
	Greenfield	3 lane	1	18,040	18,040
Ozaukee	Cedarburg	2 lane	1	12,452	12,452
Racine	Racine	4 lane	1	23,784	23,784
Walworth	Elkhorn	2 lane	1	12,452	12,452
Washington	West Bend	2 lane	1	12,452	12,452
Waukesha	Brookfield	3 lane	1	18,040	18,040
	Waukesha	3 lane	1	18,040	18,040
Total					$283,840

TABLE 58. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR OPTION 3

Number of lanes	Equipment cost, $
1	107,500
2	135,000
3	162,500
4	190,000
5	217,500
6	245,000

TABLE 59. EQUIPMENT COSTS FOR OPTION 3

County	Municipality	Configuration	Number of facilities	Equipment cost per facility	Total cost of equipment
Brown	Green Bay	2 lane	1	$135,000	$135,000
	Bellevue	2 lane	1	$135,000	$135,000
Dane	Madison	3 lane	1	$162,500	$162,500
	Suburbs	3 lane	1	$162,500	$162,500
Kenosha	Kenosha	3 lane	1	$162,500	$162,500
Milwaukee	Milwaukee	5 lane	3	$217,500	$652,500
	Greenfield	3 lane	1	$162,500	$162,500
Ozaukee	Cedarburg	2 land	1	$135,000	$135,000
Racine	Racine	4 lane	1	$190,000	$190,000
Walworth	Elkhorn	2 lane	1	$135,000	$135,000
Washington	West Bend	2 lane	1	$135,000	$135,000
Waukesha	Brookfield	3 lane	1	$162,500	$162,500
	Waukesha	3 lane	1	$162,500	$162,500
Total Network					$2,492,500

(15 facilities)($6,000/facility) + (0.10)(890,481) = $179,048

Facilities Planning--

This element is calculated as before. For building costs of between $3 million and $6 million, 15 percent of the total building cost is used. The facility planning cost, then is equal to:

(15 percent)(3,081,875) = $462,281

Program Design--

As explained for Option 1, a cost of $100,000 is assumed for the program design estimate.

Data Handling System Development--

The costs of development of data handling software are assumed to be the same as those for Option 1; $200,000.

Personnel Training--

The numbers of personnel to be trained are as follows for Option 3:

15 managers
15 assistant managers
141 inspectors
5 maintenance persons.

The training costs for these individuals are as discussed in Section 3: $53.00, $43.00 and $16.00 for instructors, investigators, and inspectors, respectively. Using the same assumptions for training as in Option 1, training costs for Option 3 are as follows:

(15 managers)($53.00) + (15 assistant managers)($16.00)
+ (146 inspectors and maintenance persons)($16.00) = $3,371

Personnel Salaries--

The same assumptions for startup personnel requirements for Option 1 were used. Substituting the personnel numbers for Option 3, the cost of test personnel for the startup period is calculated below:

$$\Big[(15\ \text{managers})(\$1666.67/\text{month})(6\ \text{months}) + (15\ \text{asst. managers})(\$1125/\text{month})(6\ \text{months}) + (5\ \text{maintenance/calib.})(\$1000/\text{month})(1\ \text{month}) + (141\ \text{inspectors})(\$866.67/\text{month})(1\ \text{month})\Big] \times \Big[1.25\Big] = \$473,063.$$

The total personnel cost for startup then is the sum of the above two figures, or

$473,063 + $756,375 = $1,229,438

Initial Public Information Program--

As explained in Option 1, the cost for initial startup of a public relations campaign would be approximately $0.12 per vehicle inspected, or $213,000.

Annual Operating Costs

Facility Personnel--

Based on the facility staffing requirements and annual salaries associated with the various job categories, the annual personnel costs can easily be computed. These costs are shown in Table 60.

TABLE 60. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION 3

Job title	Total number of positions	Annual salary	Total annual salary for all positions
Manager	15	$20,000	$ 300,000
Assistant manager	15	13,500	270,000
Maintenance person	5	12,000	60,000
Inspectors	141	10,400	1,466,400
	Total Salaries		$2,028,900
	Overhead @ 25%		507,225
			$2,536,125

Maintenance--

Primary costs for maintenance in this option reflect equipment repairs and preventive maintenance. The annual cost of these functions is assumed to be 20 percent of the original equipment cost or:

$2,492,500 x (0.20) = $498,500

Utilities, Services, and Supplies

Utilities--

Annual costs for utilities were derived from electric usage experienced by similar facilities in other states (Arizona). For Option 3, these were found to be 120 kWh per day per lane plus 325 kWh per day per facility. Assuming the same cost per kWh as in previous options, the annual cost for all facilities is calculated below:

47 lanes	@ 120 kWh/day x $0.05 per hour x 250 days =	$ 70,500
15 facilities	@ 325 kWh/day x $0.05 per hour x 250 days =	$ 60,938
	Total utility costs per year =	$131,438

Insurance--

Based on the $1,500 per lane insurance costs assumed for Option 1, total annual insurance costs for Option 3 will be:

$$\$1,500 \times 47 = \$70,500$$

Computer Operation--

Central computer operation costs for automated inspection systems have been estimated at $0.15 per test, or $225,000, as in Option 1.

Inspection Forms--

Using the $0.03 per inspection assumption as under Option 1, the inspection form printing and distribution costs will be $45,000 per year.

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating costs of maintenance/calibration vans. Using the $8,800 annual cost per van derived in the discussion of Option 1, calibration costs will be:

$$\$8,800 \times 5 = \$44,000$$

Taxes--

The annual cost for real estate and personal property taxes were calculated based on full valuation rates for each municipality in which stations are to be located. Total taxes were found to be:

General Property Tax	$174,392
Real Estate Tax	$ 32,028
Total	$206,420

Uniforms--

Based on the assumption of $125.00 annual uniform costs, as used in Option 1, and a total of 176 uniformed employees, a total annual uniform cost of $22,000 will be experienced for Option 3.

The total annual cost of utilities, services, and supplies is shown in Table 61.

TABLE 61. ANNUAL COST OF UTILITIES, SERVICES, AND SUPPLIES - OPTION 3

Utilities	$131,438
Insurance	$ 70,500
Computer Operation	$225,000
Inspection Forms	$ 45,000
Calibration Costs	$ 44,000
Taxes	$206,420
Uniforms	$ 22,000
Total	$744,358

Annual Administrative Costs

Program Administrative Personnel--
Annual administrative personnel costs are the same for Option 3 as for Option 1. From Table 31, these are found to be $504,250 annually.

Public Information--
The annual cost for public information for Option 3 is assumed to be the same as that previously stated for Option 1, or $180,000 annually.

Personnel Training--
Using the same assumptions as for Option 1, an annual turnover of inspectors of 10 percent, or 14 employees, can be expected. This relates to an annual cost of $224 based on a cost of $16/inspector.

SUMMARY

The total cost of Option 3 is summarized in Table 62.

Initial capital costs and one-time startup costs are converted to annual figures using the amortization factors found in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars. For Option 3 this procedure is as follows:

when $i = 0.03$

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2 × column 3)
I. Capital costs			
1. Land	1,174,321	0.03	35,230
2. Buildings	3,086,875	0.067	206,821
3. Equipment	2,812,500	0.2184	614,250
II. Startup costs	2,387,138	0.2184	521,351
III. Operating costs			3,778,983
IV. Administrative costs			684,474
Total			5,841,109

TABLE 62. COST SUMMARY - OPTION 3

Primary category	Principal element	Element cost	Total category cost
I. Initial capital costs	1. Land investment	$1,174,321	
	2. Building investment	$3,086,875	
	3. Equipment costs	$2,812,500	
		Total	$7,073,696
II. One-time startup costs	1. Land acquisition	$ 179,048	
	2. Facilities planning	$ 462,281	
	3. Program design	$ 100,000	
	4. Development of data handling system	$ 200,000	
	5. Personnel training	$ 3,371	
	6. Personnel salaries and overhead	$1,229,438	
	7. Initial public information costs	$ 213,000	
		Total	$2,387,138
III. Annual operating costs	1. Facility personnel	$2,536,125	
	2. Maintenance	$ 498,500	
	3. Utilities/supplies/services	$ 774,358	
		Total	$3,778,983
IV. Annual administrative costs	1. Program administrative personnel salaries and overhead	$ 504,250	
	2. Public information	$ 180,000	
	3. Training	$ 224	
		Total	$ 684,474

when i = 0.06

Cost class		Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2 × column 3)
I.	Capital costs			
	1. Land	1,174,321	0.06	70,459
	2. Buildings	3,806,875	0.087	331,198
	3. Equipment	2,812,500	0.2374	667,687
II.	Startup costs	2,387,138	0.2374	566,707
III.	Operating costs			3,778,983
IV.	Administrative costs			684,474
	Total			6,016,980

To arrive at the uniform fee in constant dollars (f_c), the above total annual costs are divided by the number of paid inspections: 1,911,000. So, for i = 0.03:

$$f_c = \frac{5,841,109}{1,911,000} = 3.06$$

and for i = 0.06

$$f_c = \frac{6,016,980}{1,911,000} = 3.15$$

The uniform fee in actual dollars (f_a) and expressed in 1978 dollars is calculated in a similar manner:

for i = 0.03,

$$f_a = 3.81$$

and for i = 0.06

$$f_a = 3.91$$

SECTION 7

OPTION 4 – CENTRALIZED, STATE-OPERATED, LOADED-MODE EMISSIONS INSPECTION WITH SAFETY AND NOISE TESTING

OPTION DEFINITION

This option calls for a network of centralized emissions, safety, and noise inspection stations to be established by the State of Wisconsin throughout the nine-county area defined in Section 2. The emissions inspection would be a loaded-mode test, and safety and noise inspections like those described for Option 1 would be performed on all light-duty gasoline-powered vehicles under 13 years old, on an annual basis.

NETWORK REQUIREMENTS

The vehicle population to be tested in this option is the same as that described in the discussion of Option 1. A per-vehicle throughput rate of 4 minutes is also assumed, since all the inspection tasks to be performed are the same as for Option 1. Assuming the same 48-hour work week and 0.67 efficiency factor as in the previous options yields a per-lane annual throughput of

(15 vehicles/hour)(48 hours/week)(52 weeks/yr)(0.67) = 25,085 vehicles.

Since this annual per-lane throughput is exactly the same as that derived for Option 1, the county lane requirements will also be the same, as shown in Table 63. Using the same approach for facility allocation and siting in each of the counties as that described for Option 1, a 20-facility network was defined, with station locations and configurations as shown in Table 64.

OPTION COSTS

The costs associated with the implementation of this option are presented below. Reference should be made to the discussion in Section 3 concerning the analytical techniques used.

TABLE 63. TOTAL INSPECTION LANES REQUIRED TO MEET 1990 INSPECTION DEMAND

County	Number of lanes required
Brown	7
Dane	12
Kenosha	5
Milwaukee	35
Ozaukee	3
Racine	7
Walworth	3
Washington	3
Waukesha	11
Total	86

TABLE 64. INSPECTION NETWORK REQUIREMENTS FOR OPTION 4

County	Town	Number of facilities	Configuration
Brown	Green Bay	1	3-lane
	Bellevue	1	4-lane
Dane	Madison	2	4-lane
	Suburbs	1	4-lane
Kenosha	Kenosha	1	2-lane
	Bristol	1	3-lane
Milwaukee	Milwaukee	5	6-lane
	Greenfield	1	5-lane
Ozaukee	Cedarburg	1	3-lane
Racine	Racine	1	4-lane
	Rochester	1	3-lane
Walworth	Elkhorn	1	3-lane
Washington	West Bend	1	3-lane
Waukesha	Brookfield	1	6-lane
	Waukesha	1	5-lane
Total network		20	86 lanes

Capital Costs

Buildings--

As indicated in the discussion of Option 1, a building cost of $25.00 per square foot was assumed for all the centralized options. For this option, an analysis of the specific inspection tasks to be performed, including dimensions of equipment required, was made to define the general features that would be included in an inspection facility. A conceptional floor plan for a basic one-lane facility for loaded emissions inspection is shown in Figure 3, presented in Section 4. Multilane facilities would require roughly the inspection area shown times the number of lanes, although some additional space would be required for waiting and rest areas. Table 65 shows the building area requirements of facility configurations ranging from one to six lanes.

Assuming a construction cost of $25.00 as a unit cost per square foot, the actual cost estimates can be computed; these are shown in Table 66.

Land Costs--

The land costs are based on the facilities requirements, land-to-building ratio defined previously, and unit land costs. For this option, the total land cost estimate is shown in Table 67.

Adding the landimprovement costs to the raw land costs listed above yields the total land investment. The land improvements associated with paving and landscaping were described in Section 4 and are summarized in Tables 68; these factors, in terms of cost by facility configuration, are shown in Table 69. The total land improvement costs for each facility are shown in Table 70.

Equipment Costs--

The equipment items required for this option are identical to those for Option 1. A summary of these is provided in Table 71. The costs for equipment items shown in Table 71 can be summarized by facility configuration; such a summary is provided in Table 72.

The total cost for equipment can now be computed based on the number of facilities by configuration, developed previously. These costs are shown in Table 73. Two additional items must be included with equipment costs; these include calibration vans and equipment, and a central computer. The number of vans is a function of the specific program scope, therefore will vary according to the particular option being considered. Only one computer is required for each option.

For Option 4, it is estimated that nine vans would be required. The estimated unit cost for the van plus calibrating gases and equipment is $14,000. The total cost, then, is $126,000.

A cost of $250,000 for the computer was suggested by several manufacturers, including Digital, Olivetti, and Sperry Univac.

TABLE 65. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS - OPTION 4

Configuration	Floor area required (ft^2)						
	Test area	Administration	Employee rest	Storage	Waiting	Restrooms	Total
1-lane	3,200	1,000	300	350	960	85	5,895
2-lane	6,400	1,000	350	400	1,440	85	9,675
3-lane	9,600	1,000	410	450	2,240	85	13,785
4-lane	12,800	1,000	450	500	3,360	85	18,195
5-lane	16,000	1,000	500	550	4,800	85	22,935
6-lane	19,200	1,000	550	600	6,560	85	27,995

TABLE 66. BUILDING COST ESTIMATES FOR OPTION 4

	Facility configuration	Per facility cost ($)	Number facilities required	Total cost ($)
Brown	3-lane	344,625	1	344,625
	4-lane	454,875	1	454,875
Dane	4-lane	454,875	3	1,364,625
Kenosha	2-lane	241,875	1	241,875
	3-lane	344,625	1	344,625
Milwaukee	6-lane	699,875	5	3,499,375
	5-lane	573,375	1	573,375
Ozaukee	3-lane	344,625	1	344,625
Racine	4-lane	454,875	1	454,875
	3-lane	344,625	1	344,625
Walworth	3-lane	344,625	1	344,625
Washington	3-lane	344,625	1	344,625
Waukesha	6-lane	699,875	1	699,875
	5-lane	573,375	1	573,375
Total				9,930,000

TABLE 67. LAND COSTS FOR EACH INSPECTION FACILITY IN OPTION 4

County	Municipality	Facility configuration	Number of facilities	Total building area (ft^2)	Land area (ft^2)	Unit cost of land ($\$/ft^2$)	Total land cost ($)
Brown	Green Bay	3	1	13,785	68,925	1.70	117,173
	Bellevue	4	1	18,195	90,975	1.00	90,975
Dane	Madison	4	2	36,390	181,950	2.00	363,900
	Suburbs	4	1	18,195	90,975	1.00	90,975
Kenosha	Kenosha	2	1	9,675	48,375	1.70	82,238
	Bristol	3	1	13,785	68,925	1.70	117,173
Milwaukee	Milwaukee	6	5	139,975	699,875	1.50	1,049,813
	Greenfield	5	1	22,935	114,675	1.50	172,013
Ozaukee	Cedarburg	3	1	13,785	68,925	0.60	41,355
Racine	Racine	4	1	18,195	90,975	0.75	68,231
	Rochester	3	1	13,785	68,925	0.75	51,694
Walworth	Elkhorn	3	1	13,785	68,925	0.67	46,180
Washington	West Bend	3	1	13,785	68,925	0.85	58,586
Waukesha	Brookfield	6	1	27,995	139,975	2.50	349,938
	Waukesha	5	1	22,935	114,675	2.50	286,688
				397,200	1,986,000		2,986,932

TABLE 68. PAVEMENT AND LANDSCAPING REQUIREMENTS FOR OPTION 4 FACILITIES

Facility configuration	Total area	Paved area (ft^2)	Landscaped area (ft^2)
1 lane	29,475	6,620	16,960
2 lane	48,375	13,105	25,595
3 lane	68,925	19,725	35,415
4 lane	90,975	25,940	46,840
5 lane	114,680	32,560	59,185
6 lane	139,980	38,775	73,210

TABLE 69. LAND IMPROVEMENT COSTS FOR INSPECTION SITES UNDER OPTION 4

Facility configuration	Pavement Cost	Landscaping Cost	Total Improvement Cost
1 lane	$ 5,296	$ 4,240	$ 9,536
2 lane	10,484	6,399	16,883
3 lane	15,780	8,854	24,634
4 lane	20,752	11,710	32,462
5 lane	26,048	14,796	40,844
6 lane	31,020	18,303	49,323

TABLE 70. LAND IMPROVEMENT COSTS FOR FACILITIES UNDER OPTION 4

County	Municipality	Facility configuration	Number of facilities	Cost per facility	Total improvement cost
Brown	Green Bay	3	1	$24,634	$ 24,634
	Bellevue	4	1	32,462	32,462
Dane	Madison	4	2	32,462	64,924
	Suburbs	4	1	32,462	32,462
Kenosha	Kenosha	2	1	16,883	16,883
	Bristol	3	1	24,634	24,634
Milwaukee	Milwaukee	6	5	49,323	246,615
	Greenfield	5	1	40,844	40,844
Ozaukee	Cedarburg	3	1	24,634	24,634
Racine	Racine	4	1	32,462	32,462
	Rochester	3	1	24,634	24,634
Walworth	Elkhorn	3	1	24,634	24,634
Washington	West Bend	3	1	24,634	24,634
Waukesha	Brookfield	6	1	49,323	49,323
	Waukesha	5	1	40,844	40,844
					$704,623

The total land investment, then, is $2,986,932 + $704,623 = $3,690,555 .

TABLE 71. MAJOR EQUIPMENT ITEMS REQUIRED FOR OPTION 4

Program element	Item	Remarks	Unit cost ($)
I. Emissions	1. Chassis dynamometer	Needed for loaded-mode emission test. One unit per test lane required. Cost based on conversations with manufacturers (Clayton, Maxwell).	14,000
	2. Emission analyzer	Since loaded-mode is used, analyzer should be capable of measuring CO, HC, and NO_x. Extremely wide range in analyzer costs; cheaper analyzers found to be inadequate. Analyzers should be capable of being tied into computer data handling system. Costs based on discussions with manufacturers (Olson-Horiba, Hamilton Test Systems). One unit per test lane required.	26,500
II. Safety	1. Dynamic brake tester	Analyzes relative and overall braking effort. One required per lane. Costs based on discussion with manufacturer's representative (Clayton, Hofman, Bear, Sum, Maxwell, Weaver).	14,000
	2. Scuff gauges	One required per lane. Cost estimate based on discussion with manufacturer's representative (AAMCO, Weaver).	800
	3. Dynamic alignment	One unit required per lane. Cost estimate based on discussion with manufacturer's representative (Hunter, Dunlop, Bear)	25,000
	4. Headlight-aim photocell	One system required per lane. Cost based on discussion with manufacturer's representative (Hunter, Bear).	625
	5. Chassis lift	One required per lane. Cost based on discussion with manufacturer's representative (AAMCO).	4,000
III. Noise	1. Sound lèvel meter	One required per lane. Cost based on discussions with B&K Instruments and GenRad.	650
IV. Data Systems	1. CRT Terminals	Two required per lane. Costs based on literature and discussions with manufacturer's representatives (Honeywell, Digital, Olivetti, Sperry Univac), and experiences of other states.	2,500
	2. Mini-computer	One required per facility (equivalent to Digital PDP-11-05). Generally assumed to be included in the cost of facility furnishings.	80,000
V. Miscellaneous	1. Miscellaneous tools	As required.	1,000

TABLE 72. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR OPTION 4

Number of lanes	Equipment cost
1	$171,575
2	263,150
3	354,725
4	446,300
5	537,875
6	629,450

TABLE 73. EQUIPMENT COSTS FOR OPTION 4

County	Town	Facility configuration	Number of facilities required	Equipment cost per facility	Total cost of equipment
Brown	Green Bay	3-lane	1	$ 354,725	$ 354,725
	Bellevue	4-lane	1	446,300	446,300
Dane	Madison	4-lane	2	446,300	892,600
	Suburbs	4-lane	1	446,300	446,300
Kenosha	Kenosha	2-lane	1	263,150	263,150
	Bristol	3-lane	1	354,725	354,725
Milwaukee	Milwaukee	6-lane	5	629,450	3,147,250
	Greenfield	5-lane	1	537,875	537,875
Ozaukee	Cedarburg	3-lane	1	354,725	354,725
Racine	Racine	4-lane	1	446,300	446,300
	Rochester	3-lane	1	354,725	354,725
Walworth	Elkhorn	3-lane	1	354,725	354,725
Washington	West Bend	3-lane	1	354,725	354,725
Waukesha	Brookfield	6-lane	1	629,450	629,450
	Waukesha	5-lane	1	537,875	537,875
					$9,475,450

One-Time Start-Up Costs

Land Acquisition--

Land acquisition costs reflect the effort required to locate and evaluate candidate sites, perform required surveying, negotiate price, and convey title. As explained in Section 3, these costs are computed on the basis of $6,000 per site to cover locating, evaluating, and performing surveys, plus 10 percent of the purchase price to cover the costs associated with conveying the title.

For this option, a total of 20 sites are required, reflecting a total land investment (basic cost only) of $2,986,932. The acquisition cost, then, is:

$$(20 \text{ facilities})(\$6{,}000/\text{facility}) + (0.10)(\$2{,}986{,}932)$$

$$= \$120{,}000 + \$298{,}693 = \$418{,}693 \,.$$

Facilities Planning--

This element is computed as a function of the total building construction cost. Specifically, for building construction costs less than $3 million, the facilities planning cost is 20 percent of the construction cost; for costs between $3 million and $6 million, 15 percent is used, and for building costs greater than $6 million, 10 percent is used. Since the building cost for this option is $9,828,500, the estimated planning cost would be 10 percent of that, or $982,850.

Program Design--

Based on both an analysis of the likely requirements specific to Wisconsin, and the experience of other states, a cost of $100,000 was arrived at for the program design estimate.

Data Handling Software--

Based on discussions with computer systems analysts, an estimate of $200,000 was developed.

Personnel Training--

As indicated in Section 3, an initial, intensive training effort is required prior to program start up. Discussions with states and private contractors involved with I/M program operation, the personnel requirements for each facility was derived. The allocation of personnel are:

- One manager and one assistant manager per facility;
- Three inspectors per test lane for emission testing only;
- Four inspectors per test lane for combined emission, safety, and noise testing; and
- One maintenance person for every 10 lanes.

Applying these rates to the facility requirements developed previously, the basic operating personnel requirements for Option 4 are:

- 20 managers
- 20 assistant managers
- 344 inspectors
- 9 maintenance persons.

The training cost per individual, as discussed in Section 3, are \$53.00, \$43.00, and \$16.00, for instructors, investigators, and inspectors. Assuming that (1) the managers are to be trained as instructors, (2) assistant managers are to be trained at the inspector level, and (3) inspectors are to be trained at the inspector level, the total cost of training can be determined. This is computed as:

$$(20 \text{ managers})(\$53.00) + (20 \text{ assistant managers})(\$16.00)$$
$$+ (344 \text{ inspectors})(\$16.00) = \$6{,}884.00 \ .$$

Personnel Salaries--

Assuming (1) that all managerial personnel would be phased into the program 6 months prior to start up; (2) that inspectors would be phased into the program 1 month prior to start up; and (3) that the wage scale (a) for managers is \$20,000 per year (\$1,667.00 per month), (b) for assistant managers is \$13,500 per year (\$1,125.00 per month), (c) for maintenance personnel is \$12,000 per year (\$1,000.00 per month), and (d) for inspectors is \$10,400 per year (\$867.00 per month), and (e) overhead is computed as 25 percent of the wage rate; a total personnel cost estimate for start up can be derived. This is:

$$\Big[(20 \text{ managers})\ (\$1{,}667.00 \text{ per month})\ (6 \text{ months})$$
$$+ (20 \text{ assistant managers})\ (\$1{,}125.00 \text{ per month})\ (6 \text{ months})$$
$$+ (9 \text{ maintenance persons})\ (\$1{,}000.00 \text{ per month})\ (1 \text{ month})$$
$$+ (344 \text{ inspectors})\ (\$867.00 \text{ per month})\ (1 \text{ month})\Big]\ \Big[1.25\Big]$$
$$= \$802{,}860.00 \ .$$

The administrative personnel cost requirements, reflecting the longer start up period, increase to \$1,260,625. A detailed discussion of these administrative personnel and associated costs is provided in Section 4.

The total personnel cost for start up, then, is:

$$\$802{,}860 + \$1{,}260{,}625 = \$2{,}063{,}485 \ .$$

Annual Operating Costs

Facility Personnel--

Based on the facility staffing requirements and annual salaries associated with the various job categories, the annual personnel costs can easily be computed. These costs are shown in Table 74.

TABLE 74. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION 4

Job title	Total number of positions	Annual salary	Total annual salary for all positions
Manager	20	$20,000	$ 400,000
Assistant manager	20	13,500	270,000
Maintenance person	9	12,000	108,000
Inspector	344	10,400	3,577,600
Total Salaries			4,355,600
Overhead at 25 percent			1,088,900
Total Annual Personnel Cost			5,444,500

Maintenance--

Primary costs for maintenance in this option reflect equipment repair and preventive maintenance. The annual cost of these functions is assumed to be 20 percent of the original equipment cost, as in Option 1, or:

$$\$9,475,450 \times (0.20) = \$1,895,090 .$$

Utilities, Services and Supplies

Utilities--

Annual costs for utilities were derived from electric usages experienced by similar facilities in other states (Arizona). For Option 4, these were found to be 120 kilowatt-hours per day per lane, plus 325 kilowatt-hours per facility. Power costs were obtained from Wisconsin Power and Light, and are assumed to be $0.05 per kilowatt-hour, on average. The annual cost for all facilities is calculated below:

86 lanes at 120 kWh/day × $0.05/kWh × 250 days/yr = $129,000 per year;

20 facilities at 325 kWh/day × $0.05/kWh × 250 days/yr = $81,250 per year;

Total utility cost = $129,000 + $81,250 = $210,250.

Insurance--

Based on the $1,500 per lane insurance costs assumed for Option 1, total annual insurance costs for Option 4 will be:

$$\$1,500 \times 86 \text{ lanes} = \$129,000 .$$

Computer Operation--

Central computer operation costs for automated inspection systems have been estimated at $0.15 per test, or $225,000, as in Option 1.

Inspection Forms--

Using the $0.03 per inspection assumption as under Option 1, the inspection form printing and distribution costs will be $45,000 per year.

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating cost of maintenance/calibration vans. Using the $8,800 annual cost per van derived in the discussion of Option 1, calibration costs will be:

$$\$8,800 \times 9 = \$79,200 .$$

Uniforms--

Based on the assumption of $125.00 annual uniform costs, as used in Option 1, and a total of 393 uniformed employees, a total annual uniform cost of $49,125 will be experienced for Option 4.

The total annual cost of utilities, services, and supplies for Option 4 is shown in Table 75.

TABLE 75. ANNUAL COST OF UTILITIES, SERVICES, AND SUPPLIES FOR OPTION 4

Item	Annual cost
Utilities	$210,250
Insurance	129,000
Computer operation	225,000
Inspection forms	45,000
Calibration cost	79,200
Uniforms	49,125
Total	$737,575

Annual Administrative Costs

Program Administrative Personnel--
The annual administrative personnel costs for Option 4 are the same as for Option 1, or $504,250.

Public Information--
The same cost, $180,000, was assumed for both Options 1 and 4.

Personnel Training--
The training costs for this element are the same as for Option 1; these are $560.

SUMMARY

The total cost of Option 4 is summarized in Table 76.

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors found in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars. For Option 4, this procedure is as follows:

when i = 0.03

Cost class	Cost	Amortization factor for i = 0.03	Annualized cost (column 2 × column 3)
I. Capital costs			
1. Land	$3,691,555	0.03	$ 110,747
2. Buildings	9,828,500	0.067	658,509
3. Equipment	9,851,450	0.2184	2,151,557
II. Startup costs	3,984,872	0.2184	870,296
III. Operating costs			8,077,452
IV. Administrative costs			684,810
Total			$12,553,340

when i = 0.06

	Cost class	Cost	Amortization factor for i = 0.06	Annualized cost (column 2 × column 3)
I.	Capital costs			
	1. Land	$3,691,555	0.06	$ 221,493
	2. Buildings	9,828,500	0.087	855,080
	3. Equipment	9,851,450	0.2374	2,338,734
II.	Startup costs	3,984,872	0.2374	946,008
III.	Operating costs			8,077,452
IV.	Administrative costs			684,810
	Total			$13,123,577

To arrive at the uniform fee in constant dollars (f_c), the above total annual costs are divided by the number of paid inspections: 1,911,000. So, for i = 0.03:

$$f_c = \frac{12,553,340}{1,911,000} = 6.57$$

and for i = 0.06:

$$f_c = \frac{13,123,577}{1,911,000} = 6.87$$

The uniform fee in actual dollars (f_a) and expressed in 1978 dollars is calculated in a similar manner:

for i = 0.03, $f_a = 8.75$

and for i = 0.06, $f_a = 9.08$

BENEFITS

The discussion on benefits provided in Option 1 applies identically to this option. This is also true of the additional discussion on safety inspection programs presented in Option 1, as well.

TABLE 76. COST SUMMARY - OPTION 4

Primary cost category	Principal element	Element cost	Total category cost
I. Initial capital costs	1. Land investment	$3,691,555	
	2. Building investment	9,828,500	
	3. Equipment costs	9,475,450	
Total			$22,995,505
II. One-time startup costs	1. Land acquisition	418,693	
	2. Facilities planning	982,850	
	3. Program design	100,000	
	4. Development of data handling system hardware	200,000	
	5. Personnel training	6,844	
	6. Personnel salaries and overhead	2,063,485	
	7. Initial public information costs	213,000	
Total			3,984,872
III. Annual operating costs	1. Facility personnel	5,444,500	
	2. Maintenance	1,895,090	
	3. Utilities/supplies/services	737,575	
Total			8,077,165
IV. Annual administrative costs	1. Program administrative salaries and overhead	504,250	
	2. Public information	180,000	
	3. Training	224	
Total			684,474

SECTION 8

OPTION 5 - CENTRALIZED, STATE-OPERATED, IDLE MODE EMISSIONS TEST

OPTION DEFINITION

This option calls for a network of centralized idle-mode emissions inspection stations to be established by the State of Wisconsin throughout the nine-county area defined in Section 2. Coverage would include all light-duty gasoline-powered vehicles under 13 years old on an annual basis.

NETWORK REQUIREMENTS

The vehicle population to be tested in this option is the same as that described in the discussion of option 1. A per-vehicle throughput rate of 2 minutes has been assumed, since all inspection tasks to be performed are the same as those described for option 3. Assuming the same 48-hour work week and 0.67 efficiency factor yields an annual per-lane throughput of

$$(30 \text{ vehicles/hour}) (48 \text{ hours/week}) (52 \text{ weeks/year}) (0.67) = 50{,}170 \text{ vehicles}$$

Since this annual per-lane throughput is exactly the same as that derived for option 3, the county lane requirements will also be the same as shown in Table 77. Since the same approach for facility siting and allocation was also used, an identical network to that derived for Option 3, with 15 stations and 47 lanes, was arrived at, as shown in Table 78.

OPTION COSTS

The costs associated with the implementation of this option are presented below. Reference should be made to the discussion in Section 3 concerning the analytical techniques used.

Capital Costs

Buildings--

As indicated in the discussion of option 1, building cost of $25.00 per square foot was assumed for all the centralized facility options. For this option, analysis of the specific tasks required for idle-mode inspection, including dimensions of equipment required, was made to define the general features that would be included in an inspection facility. A conceptual

TABLE 77. TOTAL INSPECTION LANES REQUIRED TO MEET 1990 INSPECTION DEMAND

County	Number of lanes required
Brown	4
Dane	6
Kenosha	3
Milwaukee	18
Ozaukee	2
Racine	4
Walworth	2
Washington	2
Waukesha	6
Total	47

TABLE 78. INSPECTION NETWORK REQUIREMENTS FOR OPTION 5

County	Town	Number of facilities	Configuration
Brown	Green Bay	1	2-lane
	Bellevue	1	2-lane
Dane	Madison	1	3-lane
	Suburbs	1	3-lane
Kenosha	Kenosha	1	3-lane
Milwaukee	Milwaukee	3	5-lane
	Greenfield	1	3-lane
Ozaukee	Cedarburg	1	2-lane
Racine	Racine	1	4-lane
Walworth	Elkhorn	1	2-lane
Washington	West Bend	1	2-lane
Waukesha	Brookfield	1	3-lane
	Waukesha	1	3-lane
Total network		15	47 lanes

floor plan for a basic one-lane facility for idle-mode inspection is shown in Figure 6. Multilane facilities would require roughly the inspection area shown times the number of lanes, although some additional space would be required for waiting and rest areas, etc. Table 79 shows the building area requirements of facility configurations ranging from one to six lanes.

Taking $25.00 as a unit building cost per square foot, the actual cost estimates for network facilities can be computed for this option, and are shown in Table 80 below.

Land Costs--

The primary determinants of land cost for any option are the unit cost per square foot and the total size (in square feet) of the land to be acquired. In Section 3, the unit cost estimates for land in each county were presented, and these estimates will be used here.

Lot size requirements are a function of facility size (i.e., the number of inspection lanes). As in option 1, we will define the land : building ratio as 5:1. Thus, for each facility in the network, raw land costs can be calculated, and are shown in Table 81 below.

Adding the land improvement costs to the raw land costs listed above yields the total land investment. Standard paving and landscaping formulas, used in the Option 1 analysis, were applied to the lot requirements for this option; Table 82 lists total area, paved area, and landscaped area for each facility configuration.

The same costs per square foot used in Option 1 are assumed. The improvement costs for each type of facility are shown in Table 83.

Land improvements cost can then be calculated for the entire Option 3 network, as shown in Table 84. The total land investment, then, is

$890,481 + $283,840 = $1,174,321

Equipment Costs--

The equipment items required to operate a loaded-mode emissions inspection facility were identified through consultations with equipment manufacturers and state and local officials. For this option, the equipment required is an automated CO/HC analyzer which costs $21,500. When added to computer facilities and miscellaneous tools, the total equipment investment as a function of facility configuration is shown in Table 85.

The total cost for equipment in the Option 5 network can be computed based on the number of facilities by configuration developed previously. These costs are shown in Table 86.

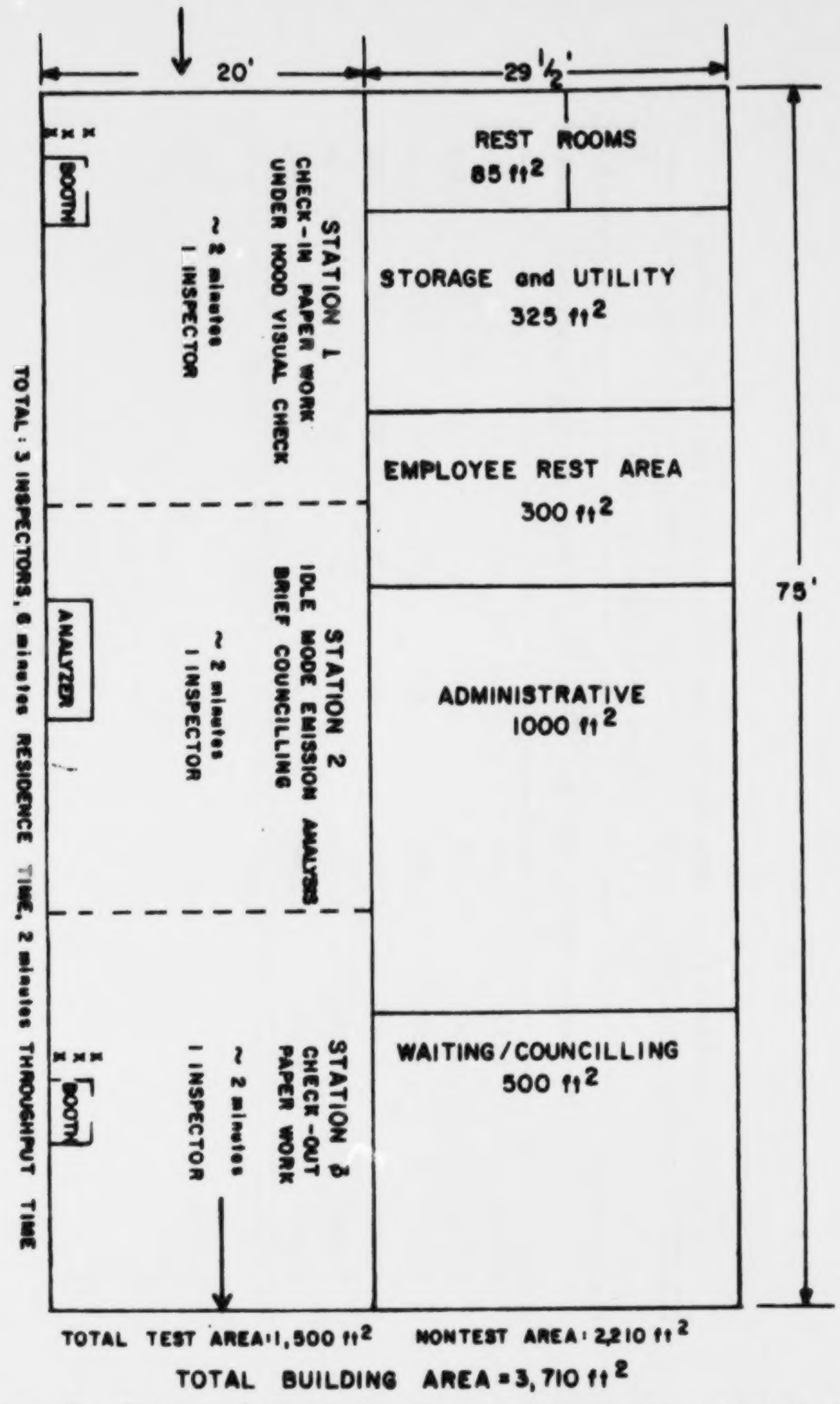
20'
29 1/2'
75'
REST ROOMS
85 ft²
STORAGE and UTILITY
325 ft²
EMPLOYEE REST AREA
300 ft²
ADMINISTRATIVE
1000 ft²
WAITING/COUNCILLING
500 ft²
STATION 1
CHECK-IN PAPER WORK
UNDER HOOD VISUAL CHECK
~2 minutes
1 INSPECTOR
BOOTH
STATION 2
IDLE MODE EMISSION ANALYSIS
BRIEF COUNCILLING
~2 minutes
1 INSPECTOR
ANALYZER
STATION 3
CHECK-OUT
PAPER WORK
~2 minutes
1 INSPECTOR
BOOTH
TOTAL: 3 INSPECTORS, 6 minutes RESIDENCE TIME, 2 minutes THROUGHPUT TIME
TOTAL TEST AREA: 1,500 ft²
NONTEST AREA: 2,210 ft²
TOTAL BUILDING AREA = 3,710 ft²

Figure 6. Conceptual floor plan for an idle-mode inspection facility.

TABLE 79. BUILDING FLOOR AREA FOR VARIOUS FACILITY CONFIGURATIONS - OPTION 5

Configuration	Floor area required (ft^2)						
	Test area	Administration	Employee rest	Storage	Waiting	Restrooms	Total
1-lane	1,500	1,000	300	325	500	85	3,710
2-lane	3,000	1,000	330	350	850	85	5,615
3-lane	4,500	1,000	375	375	1,450	85	7,785
4-lane	6,000	1,000	400	400	2,300	85	10,185
5-lane	7,500	1,000	450	425	3,375	85	12,835
6-lane	9,000	1,000	480	425	4,700	85	15,690

TABLE 80. BUILDING COST ESTIMATE FOR OPTION 5

County	Facility configuration	Per facility cost ($)	Number facilities required	Total costs ($)
Brown	2-lane	140,375	2	280,750
Dane	3-lane	194,625	2	389,250
Kenosha	3-lane	194,625	1	194,625
Milwaukee	5-lane	320,875	3	962,625
	3-lane	194,625	1	194,625
Ozaukee	2-lane	140,375	1	140,375
Racine	4-lane	254,625	1	254,625
Walworth	2-lane	140,375	1	140,375
Washington	2-lane	140,375	1	140,375
Waukesha	3-lane	194,625	2	389,250
Total network	47 lanes	15 facilities		3,086,875

TABLE 81. LAND COSTS FOR EACH INSPECTION FACILITY IN OPTION 5

County	Municipality	Facility configuration	Number of facilities	Total building area (ft^2)	Land area (ft^2)	Unit cost of land ($/ft^2	Total land cost ($)
Brown	Green Bay	2-lane	1	5,615	28,075	1.70	47,728
	Bellevue	2-lane	1	5,615	28,075	1.00	28,075
Dane	Madison	3-lane	1	7,785	38,925	2.00	77,850
	Suburbs	3-lane	1	7,785	38,925	1.00	38,925
Kenosha	Kenosha	3-lane	1	7,785	38,925	1.70	66,173
Milwaukee	Milwaukee	5-lane	3	38,505	192,525	1.50	288.788
	Greenfield	3-lane	1	7,785	38,925	1.50	58,388
Ozaukee	Cedarburg	2-lane	1	5,615	28,075	0.60	16,845
Racine	Racine	4-lane	1	10,185	50,925	0.75	38,194
Walworth	Elkhorn	2-lane	1	5,615	28,075	0.67	18,810
Washington	West Bend	2-lane	1	5,615	28,075	0.85	23,864
Waukesha	Brookfield	3-lane	1	7,785	38,925	2.50	97,313
	Waukesha	3-lane	1	7,785	38,925	2.30	89,528
Total		47 lanes	15	123,475	617,375		890,481

TABLE 82. PAVEMENT AND LANDSCAPING REQUIREMENTS FOR OPTION 5 FACILITIES

Facility configuration	Total area	Paved area (ft^2)	Landscaped area (ft^2)
1 lane	18,550	6,215	8,625
2 lane	28,075	12,430	10,030
3 lane	38,925	18,645	12,495
4 lane	50,925	24,725	16,015
5 lane	64,175	30,940	20,400
6 lane	78,450	37,020	25,740

TABLE 83. LAND IMPROVEMENT COSTS FOR INSPECTION FACILITY SITES UNDER OPTION 5

Facility configuration	Pavement cost	Landscaping cost	Total improvement cost
1 lane	$ 4,972	$2,156	$ 7,128
2 lane	9,944	2,508	12,452
3 lane	14,916	3,124	18,040
4 lane	19,780	4,004	23,784
5 lane	24,752	5,100	29,852
6 lane	29,616	6,435	36,051

TABLE 84. LAND IMPROVEMENT COSTS FOR FACILITIES UNDER OPTION 5

County	Municipality	Facility configuration	Number of facilities	Cost per facility	Total improvement cost
Brown	Green Bay	2-lane	1	$12,452	$ 12,452
	Bellevue	2-lane	1	12,452	12,452
Dane	Madison	3-lane	1	18,040	18,040
	Suburbs	3-lane	1	18,040	18,040
Kenosha	Kenosha	3-lane	1	18,040	18,040
Milwaukee	Milwaukee	5-lane	3	29,852	89,556
	Greenfield	3-lane	1	18,040	18,040
Ozaukee	Cedarburg	2-lane	1	12,452	12,452
Racine	Racine	4-lane	1	23,784	23,784
Walworth	Elkhorn	2-lane	1	13,452	12,452
Washington	West Bend	2-lane	1	12,452	12,452
Waukesha	Brookefield	3-lane	1	18,040	18,040
	Waukesha	3-lane	1	18,040	18,040
					283,940

TABLE 85. EQUIPMENT COSTS AS A FUNCTION OF FACILITY CONFIGURATION FOR OPTION 5

Number of lanes	Equipment cost ($)
1	107,500
2	135,000
3	162,500
4	190,000
5	217,500
6	245,000

TABLE 86. EQUIPMENT COSTS FOR OPTION 5

County	Town	Facility configuration	Number of facilities	Equipment cost per facility	Total cost of equipment
Brown	Green Bay	2-lane	1	$135,000	$ 135,000
	Bellevue	2-lane	1	135,000	135,000
Dane	Madison	3-lane	1	162,500	162,500
	Suburbs	3-lane	1	162,500	162,500
Kenosha	Kenosha	3-lane	1	162,500	162,500
Milwaukee	Milwaukee	5-lane	3	217,500	652,500
	Greenfield	3-lane	1	162,500	162,500
Ozaukee	Cedarburg	2-lane	1	135,000	135,000
Racine	Racine	4-lane	1	190,000	190,000
Walworth	Elkhorn	2-lane	1	135,000	135,000
Washington	West Bend	2-lane	1	135,000	135,000
Waukesha	Brookfield	3-lane	1	162,500	162,500
	Waukesha	3-lane	1	162,500	162,500
Total network					$2,492,500

One-Time Startup Costs

Land Acquisition--

As before, the cost of land acquisition is assumed to be $6,000 per site plus 10 percent of the purchase price. For this option a total of 15 sites are required. The total unimproved land investment being $890,481, the acquisition cost is:

$$(15 \text{ facilities}) (\$6{,}000/\text{facility}) + (0.10) (890{,}481) = \$179{,}048$$

Facilities Planning--

This element is calculated as before. For building costs of between $3 million and $6 million, 15 percent of the total building cost is used. The facility planning cost, then, is equal to:

$$(15\%) (3{,}081{,}875) = \$462{,}281$$

Program Design--

As explained for Option 1, a cost of $100,000 is assumed for the program design estimate.

Data Handling System Development--

The costs of development of data handling software are assumed to be the same as those for Option 1: $200,000.

Personnel Training--

The numbers of personnel to be trained are as follows for Option 5:

15 Managers
15 Assistant Managers
141 Inspectors
5 Maintenance Persons

The training costs for these individuals are as discussed in Section 3, are $53.00, $43.00, and $16.00 for instructors, investigators, and inspectors, respectively. Using the same assumptions for training as in Option 1, training costs for Option 3 are as follows:

$$(15 \text{ Managers}) (\$53.00) + (15 \text{ Assistant Managers}) (\$16.00)$$
$$+ (146 \text{ inspectors and maintenance persons}) (\$16.00) = \$3{,}371$$

Personnel Salaries--

For the state-owned options, startup personnel requirements are different from privately-owned approaches, as a longer lead time is required for site acquisition, receiving of bids on equipment, etc. For administrative personnel, a startup time of 2-1/2 years is assumed; for station managers and personnel, the previously-assumed 6 months is still held to be the case. For option 5, the cost of test personnel for the startup period is calculated below:

$$[(15 \text{ managers})(\$1{,}666.67/\text{month})(6 \text{ months}) + (15 \text{ assistant managers})(\$1{,}125/\text{month})(6 \text{ months}) + (5 \text{ maintenance/calib})(\$1{,}000/\text{month})(1 \text{ month}) + (141 \text{ inspectors})(\$866.67/\text{month})(1 \text{ month})] \times [1.25] = \$473{,}063$$

The administrative personnel cost requirements, reflecting the longer startup period, increase to $1,260,625.

The total personnel cost for startup, then, is

$$\$473{,}063 + \$1{,}260{,}625 = \$1{,}733{,}688$$

Initial Public Information Program--

As explained in Option 1, the cost for initial startup of a public relations campaign would be approximately $0.12 per vehicle inspected, or $213,000.

Annual Operating Costs

Facility Personnel--

Based on the facility staffing requirements and annual salaries associated with the various job categories, the annual personnel costs can easily be computed. These costs are shown in Table 87.

TABLE 87. ANNUAL PERSONNEL COSTS FOR FACILITY PERSONNEL - OPTION 5

Job title	Total number of positions	Annual salary ($)	Total annual salary for all positions
Manager	15	20,000	$ 300,000
Assistant Manager	15	13,500	270,000
Maintenance Person	5	12,000	60,000
Inspectors	141	10,400	1,466,400
Total salaries			$2,028,900
Overhead @ 25 percent			507,225
			$2,536,125

Maintenance--

Primary costs for maintenance in this option reflect equipment repairs and preventive maintenance. The annual cost of these functions is assumed to be 20 percent of the original equipment cost or:

$$\$\,2{,}492{,}500 \times (0.20) = \$498{,}500$$

Utilities, Services, and Supplies

Utilities--

Annual costs for utilities were derived from electric usage experienced by similar facilities in other states (Arizona). For Option 5, these were found to be 20 kWh/day per lane plus 325 kWh/day per facility, assuming the same cost per kWh/hr as in previous options; the annual cost for all facilities is calculated below:

47 lanes	@ 120 kWh/day × $0.05 per hour × 250 days:	$ 70,500
15 facilities	@ 325 kWh/day × $0.05 per hour × 250 days:	$ 60,938
	Total utilities cost per year	$131,438

Insurance--

Based on the $1,500 per lane insurance costs assumed for Option 1, total annual insurance costs for Option 5 will be:

$1,500 × 41 = $70,500

Computer Operation--

Central computer operation costs for automated inspection systems have been estimated at $0.15 per test, or $225,000 as in Option 1.

Inspection Forms--

Using the $0.03 per inspection assumption as under Option 1, the inspection form printing and distribution costs will be $45,000 per yea.

Calibration Costs--

The recurring annual cost of equipment calibration is defined as the cost of calibration gases plus the operating costs of maintenance/calibration vans. Using the $8,800 annual cost per van derived in the discussion of Option 1, calibration costs will be:

$8,800 × 5 = $44,000

Uniforms--

Based on the assumption of $125.00 annual uniform costs, as used in Option 1, and a total of 393 uniformed employees, a total annual uniform cost of $49,125 will be experienced for Option 5.

The total annual cost of utilities, services, and supplies, computed in Table 88, was found to be:

TABLE 88. ANNUAL COST OF UTILITIES, SERVICES, AND SUPPLIES - OPTION 5

Utilities	$131,438
Insurance	70,500
Computer operation	225,000
Inspection forms	45,000
Calibration costs	44,000
Uniforms	49,125
Total	$565,063

Annual Administrative Costs

Program Administrative Personnel--

Annual administrative personnel costs are the same for Option 5 as for Option 1. From Table 89, these are found to be $504,250 annually.

Public Information--

The annual cost for public information for Option 5 is assumed to be the same as that previously stated for Option 1, or $180,000 annually.

Personnel Training--

Using the same assumption as for Option 1, an annual turnover of inspectors of 10 percent, or 14 employees, can be expected. This relates to an annual cost of $224 based on a cost of $16/inspector.

TABLE 89. COST SUMMARY - OPTION 5

Priamry category		Principal element	Element cost ($)	Total category cost ($)
I.	Initial capital costs	1. Land investment	1,174,321	
		2. Building investment	3,086k875	
		3. Equipment costs	2,812,500	
				7,073,696
II.	One-Time Start-Up Costs	1. Land acquisition	179,048	
		2. Facilities planning	462,281	
		3. Program design	100,000	
		4. Development of data handling system	200,000	
		5. Personnel training	3,371	
		6. Personnel salaries and overhead	1,733,688	
		7. Initial public information costs	213,000	
				2,891,388
III.	Annual Operating Costs	1. Facility personnel	2,596,125	
		2. Maintenance	498,500	
		3. Utilities/supplies/services	565,063	
				3,599,688
IV.	Annual Administrative Costs	1. Program administrative personnel salaries and overhead	504,250	
		2. Public information	180,000	
		3. Training	224	
				684,474

SUMMARY

The total cost of Option 5 is summarized in Table 89.

Initial capital costs and one-time start-up costs are converted to annual figures using the amortization factors found in Section 3. These annualized costs are added to annual operating costs and annual administrative costs to arrive at total annual costs in constant 1978 dollars. For Option 5 this procedure is as follows:

when i = 0.03

Cost class	Cost ($)	Amortization factor for i = 0.03	Annualized cost ($) (column 2)×(column 3)
I. Capital costs			
1. Land	1,174,321	0.03	35,230
2. Buildings	3,086,875	0.067	206,821
3. Equipment	2,812,500	0.2184	614,250
II. Startup costs	2,891,388	0.2184	631,479
III. Operating costs			3,599,688
IV. Administrative costs			684,474
Total			5,771,942

when i = 0.06

Cost class	Cost ($)	Amortization factor for i = 0.06	Annualized cost ($) (column 2)×(column 3)
I. Capital costs			
1. Land	1,174,321	0.06	70,459
2. Buildings	3,086,875	0.087	268,558
3. Equipment	2,812,500	0.2374	667,687
II. Start-up costs	2,891,388	0.2374	686,416
III. Operating costs			3,599,688
IV. Administrative			684,474
Total			5,977,312

To arrive at the uniform fee in constant dollars (f_c), the above total annual costs are divided by the number of paid inspections: 1,911,000. So, for i = 0.03:

$$f_c = \frac{5,771,942}{1,911,000} = 3.020$$

and for i = 0.06

$$f_c = \frac{5,977,312}{1,911,000} = 3.128$$

The uniform fee in actual dollars (f_a) and expressed in 1978 dollars is calculated in a similar manner:

for i = 0.03,

$$f_a = 3.835$$

and for i = 0.06

$$f_a = 3.932$$

SECTION 9

DECENTRALIZED PROGRAM OF IDLE MODE EMISSIONS TESTING

OPTION DEFINITION

A decentralized approach to emissions testing utilizes existing private garages and the personnel employed by them to conduct the actual vehicle testing procedure. Each station participating in I/M inspection must have an HC/CO analyzer that is inspected and certified routinely by the state agency overseeing the program.

To accomplish this periodic certification the state will need mobile vans that have been suitably equipped to test the accuracy of HC/CO analyzers owned by participating private garages. To maintain program integrity a referee or challenge inspection lane should be operated by the state. Should a vehicle owner disagree with the results of a test performed by a private garage he may have the test repeated at the challenge lane. The results of a challenge lane test are final.

There will be certain administrative personnel required at the state level to oversee the equipment certification procedure, licensing of private garages to perform inspections and coordinate the program in general.

NETWORK DEVELOPMENT

Relevant Vehicle Population

In order to properly determine minimum and maximum acceptable inspection station networks the number of vehicle inspections that must be performed in 1987 is needed. This figure can be estimated based on 1977 vehicle registrations in the program area. The vehicle population estimates for 1987 are based on the assumption that the quantity of light duty vehicles is increasing at a constant rate of 3 percent per year. Total inspections required in 1987 appear in the right hand column of Table 90 and assume a stringency rate of 30 percent and that no vehicle fails re-inspection.

TABLE 90. VEHICLE REGISTRATIONS AND INSPECTIONS FOR SELECTED COUNTIES FOR 1987

County	1987 registrations	1987 inspections
Brown	119,697	155,606
Dane	255,437	293,068
Kenosha	87,871	114,232
Milwaukee	657,037	854,148
Ozaukee	50,226	65,294
Racine	124,734	162,154
Walworth	52,410	68,133
Washington	57,712	75,026
Waukesha	205,245	266,819
Total	1,580,369	2,054,480

Private Garages Available to Perform I/M Inspections

Table 91 is based on 1972 figures on the number of auto repair shops, dealers and gasoline service stations as published in Motor/Age. It is calculated with the assumption that 1987 figures will be 60 percent of their 1972 values. This anticipated decline is based on several things. First, the number of service stations has been declining since 1972. Self-serve stations that have no maintenance facilities at all are growing in popularity and are likely to continue to do so in the future. Finally, a certain proportion of these facilities will simply not be interested in becoming involved with I/M for various reasons.

TABLE 91. PRIVATE GARAGES ELIGIBLE TO PARTICIPATE IN I/M IN 1987

County	Number of garages
Brown	159
Dane	308
Kenosha	124
Milwaukee	784
Ozaukee	56
Racine	164
Walworth	91
Washington	79
Waukesha	208
Total	1,973

There is no reason why all, or any arbitrarily chosen number of these garages should be included in an I/M network. The analysis that follows derives minimum and maximum levels of private garage participation based on assumptions about variables that determine private garage performance and profitability.

Minimum Private Garage Networks

The minimum number of private garages is determined by the number of inspections that must be performed each year. The following formula determines this minimum:

$$G = \frac{I}{DN}$$

where: G = the number of garages required to participate in an I/M program

I = total number of inspections performed per year

D = number of inspection days per year

N - number of vehicles inspected by each garage each day.

The number of garages (G) is inversely related to throughput rate (N). Maximizing N will minimize G. Thus, G is dependent on the maximum number of vehicles that can be processed per station per day.

The maximum number of vehicles that can be reasonably handled at a service station is 21 per day or 5,250 per year.[1] Using this figure and Table 91, the following figures can be computed:

TABLE 92. MINIMUM PRIVATE GARAGE NETWORK NEEDED IN 1987

County	Number of garages
Brown	30
Dane	56
Kenosha	22
Milwaukee	163
Ozaukee	13
Racine	31
Walworth	13
Washington	13
Waukesha	51
Total	394

Service Area Radius and Market Participation Rate--

There are two concepts that are useful in evaluating a private garage network. They are service area radius and extent of market participation by garages in an I/M scheme.

The concept of service area radius assumes that no motorist needs to travel more than distance R to reach an inspection facility. It assumes vehicles and garages are spread out evenly across the landscape. R is the radius of a service station's area of coverage and that area is equal to πR^2. If the number of garages (G) in an area is known, R can be determined with the following formula:

$$R = \sqrt{\frac{A}{\pi G}}$$

where: R = service area radius

A = given geographical area

π = 3.14159

G = number of garages in area A

Market participation is a figure that represents the number of private garages participating as inspection stations as a percentage of the total number of facilities that could be used for I/M in a given area. While this figure doesn't affect the calculated minimum and maximum network sizes, it is useful because it gives an idea of how easily the number of inspection sites can be changed. The market participation rate can be determined with the following equation:

$$P = \frac{G}{T}$$

where: P = market participation, expressed in percent

G = number of private garages serving as inspection stations in a given area

T = total number of private garages within that same area.

Minimum Network Service Area Radii and Market Participation Rates--

Using the equations above, the following figures result for a minimum private garage network:

TABLE 93. MINIMUM SERVICE AREA RADII AND MARKET PARTICIPATION RATES

County	Service area radius (miles)	Market participation (percent)
Brown	2.36	18.9
Dane	2.60	18.2
Kenosha	1.98	17.7
Milwaukee	0.68	20.8
Ozaukee	2.40	23.2
Racine	1.86	18.9
Walworth	3.69	14.3
Waukesha	1.86	24.5

Maximum Private Garage Network

As the number of private garages increases the service area and throughput rates for each garage will decline. The number of inspection stations (licensed service stations) can increase beyond the minimum network described above. There is, however, a constraint on total number that can exist at any one point in time. Private garages are motivated to participate by the potential profits I/M can generate for them. The minimum revenue from I/M participation that is acceptable to private garages would be the cost they incur in purchasing the requisite equipment and wages spent for personnel performing the tests. This is illustrated in Figure 7.

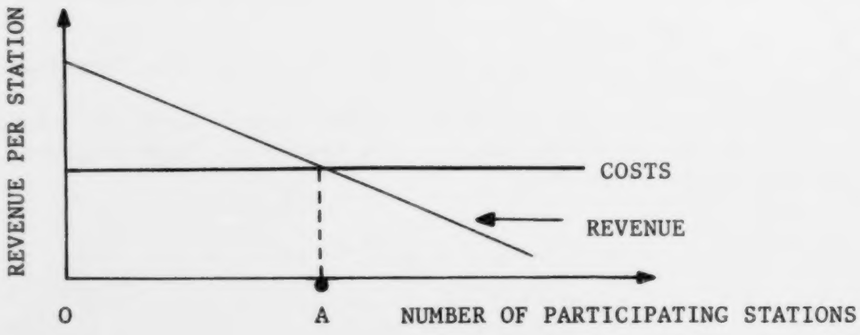

Figure 7. Market factors affecting private garage participation.

As the number of stations increases the number of inspections occurring at each station declines and revenues fall correspondingly. This is reflected by the negative slope of the revenue curve in Figure 7. Garages will continue to enter the I/M business (for that is what it is to them) until the total number of stations is equal to A. At this point each station makes zero return on its investment. Stations will operate at this seemingly irrational margin because repair business is likely to be generated for garages that have the capability to perform inspections. No stations are likely to operate in excess of A because to do so would be to operate at a loss. To the right of point A costs exceed revenues.

The formula that governs private garage market entry behavior is:

$$\text{Total Revenue (TR)} = \text{Total Cost (TC)}$$

This equation can be separated into component parts in the following manner:

$$M\,(C-F) = (A) + (S) + (L) + (O)$$

where: M = number of cars inspected per year

C = inspection charge, assumed to be $5.00

F = state fee per inspection to cover administrative costs, assumed to be $0.50

A = cost of analyzer and accessories. If a typical station purchases an analyzer and accessories costing $3,000 over a 5-year period at 8 percent interest, its annual payment will be

$$\text{Payment} = \frac{3{,}000}{\left[\dfrac{(1.08)^5 - 1)}{0.08(1.08)^5}\right]} = \$751.88$$

S = the salary of the inspector. This can be calculated using the following formula. S can be further disaggregated into its components:

$$S = (H)\ (W)\ (D)$$

where: H = number of hours per day spent performing inspections

W = the hourly wage of the inspector

D = the number of days per year spent performing inspections

L = annual licensing fees, assumed not to exceed $100.00.

O = station overhead, assumed to be 1/3 of inspector salary S.

substituting and solving for M,

$$M = \frac{(A + S + L + O)}{(C - F)}$$

$$= \frac{A + (1.33)\,(H)\,(W)\,(D) + L}{(C - F)}$$

recalling the formula

$$G = \frac{I}{DN}$$

and solving for G yields the number of garages participating in an I/M network. Since the number of cars inspected per year for one station equals the number of inspection days per year times station throughput:

$$M = DN$$

Using the above cost assumptions the number of vehicle inspections necessary for a facility to cover its costs (M) can be calculated for various salary (S) rates and operating costs (O). The minimum quantity of vehicle inspections thus calculated determine the maximum number of private garages that can be licensed for the assumed 1987 vehicle population.

Table 94 reveals the maximum number of garages that market forces will allow to operate for different inspector wages and hours per day devoted to I/M inspections.

TABLE 94. MAXIMUM PRIVATE GARAGE PARTICIPATION, (NUMBER OF GARAGES)

Hours per day spent on inspections	Inspector hourly wage rate		
	\$4.50	\$5.50	\$6.50
1	3,922*	3,441*	3,662*
2	2,400*	2,046*	1,782
3	1,728	1,455	1,257
4	1,350	1,129	970
5	1,108	923	790
6	939	780	667
7	815	676	577
8	720	596	508

*These combinations of time devoted to I/M and inspector wage rates require vehicle throughputs that are unachievable given the limited number of vehicles that can be inspected in a given year.

A reasonable combination of variables would be an inspector wage rate of \$5.50 per hour and a 4-hour inspection day and a break-even throughput rate of 1819 vehicles per year per station results.[2] Table 95 distributes the maximum garage network for a \$5.50 wage rate and 4-hour day (calculated in Table 94) over the relevant nine-county region.

TABLE 95. MAXIMUM GARAGE NETWORK FOR INSPECTOR WAGE OF \$5.50 AND 4-HOUR INSPECTION DAY

County	Number of garages needed
Brown	86
Dane	161
Kenosha	63
Milwaukee	470
Ozaukee	36
Racine	89
Walworth	37
Washington	41
Waukesha	147
Total	1,130

Maximum Network Service Area Radii and Market Participation Rates--

Applying maximum network figures to the service area radii and market participation rate formulae yields:

TABLE 96. MAXIMUM SERVICE AREA RADII AND MARKET PARTICIPATION RATES

County	Service area radius (miles)	Market participation rate (percent)
Brown	1.39	54.0
Dane	1.54	52.2
Kenosha	1.17	50.8
Milwaukee	0.40	59.9
Ozaukee	1.44	64.3
Racine	1.09	54.2
Walworth	2.19	40.6
Washington	1.82	51.9
Waukesha	1.10	70.7

MOBILE STATE INSPECTIONS OF PRIVATE GARAGES

All private facilities serving as inspection facilities should be visited by a mobile state inspector at least once a month to:

1. gather data recorded on vehicles inspected
2. follow up on complaints and inquires
3. calibrate HC/CO analyzer to ensure its accuracy

An inspection/calibration visit is likely to take 1 hour at most. If travel time between inspection visits is 30 minutes, on an average a state inspector can perform five such visits in an 8-hour day (104 per month). Assuming a 67 percent efficiency factor, they can visit 70 sites per month.

Applying this figure to the minimum and maximum private garage networks described above, inspector requirements become quantifiable.

TABLE 97. MOBILE INSPECTOR REQUIREMENTS FOR MINIMUM AND MAXIMUM PRIVATE GARAGE NETWORKS

County	Minimum network	Maximum network
Brown	0.43	1.23
Dane	0.80	2.30
Kenosha	0.31	0.90
Milwaukee	2.33	6.71
Ozaukee	0.19	0.51
Racine	0.44	1.27
Walworth	0.19	0.53
Washington	0.21	0.59
Waukesha	0.73	2.10
Total	5.63 or approximately 6	16.14 or approximately 17

COSTS

Referee Lane

The referee or challenge lane, designed to resolve vehicle owner complaints about private garage test results, is assumed to be a one-lane, idle-mode only facility. Cost breakdowns for this lane are:

Building	$ 92,750
Land	27,825
Improvements	7,128
Equipment	27,500
Total	$155,203

(Note: The methodology used in arriving at these figures is the same as that used in the main costing section.)

It is assumed that the state already has the necessary computer facilities in place. Software development costs will be $20,000 and will be written on a contract basis.

The value of equipment will be depreciated 20 percent annually.

State Manpower Requirements

State personnel that will have to be added to accommodate a private garage approach are depicted in Figure 8. They are listed and costed out in Table 98. With the exception of mobile inspector salaries these figures will remain constant regardless of whether a minimum or maximum private garate network is developed. State salary commitments vary between $695,340 and $864,740 annually.

Total Private Garage Costs

In addition to state manpower and mobile van costs (a mobile van fully equipped for inspection and licensing costs $14,000) the garages conducting I/M inspections face costs. The costs faced by private garages are HC/CO analyzer cost, mechanic's salary, licensing fee and overhead. Assuming a mechanic's wage of $5.50 per hour and 250 8-hour inspection days per year, the private garages in the minimum network will incur $17,766 in I/M costs.[3] With 394 private garages participating, the total cost to private garages totals to $6,999,804.

For a maximum network each private garage will incur $10,433 in I/M costs.[4] This calculation assumes mechanic salary to be $5.50 per hour and 250 4-hour inspection days per year. With 1,130 stations participating, private garage costs for the maximum network total to $11,789,290.

System Costs

Table 99 summarizes the total costs for both the minimum and maximum private garage networks. In addition to the total costs born by private garages, the State expense for a minimum network is $974,543 and $1,327,943 for a maximum network.

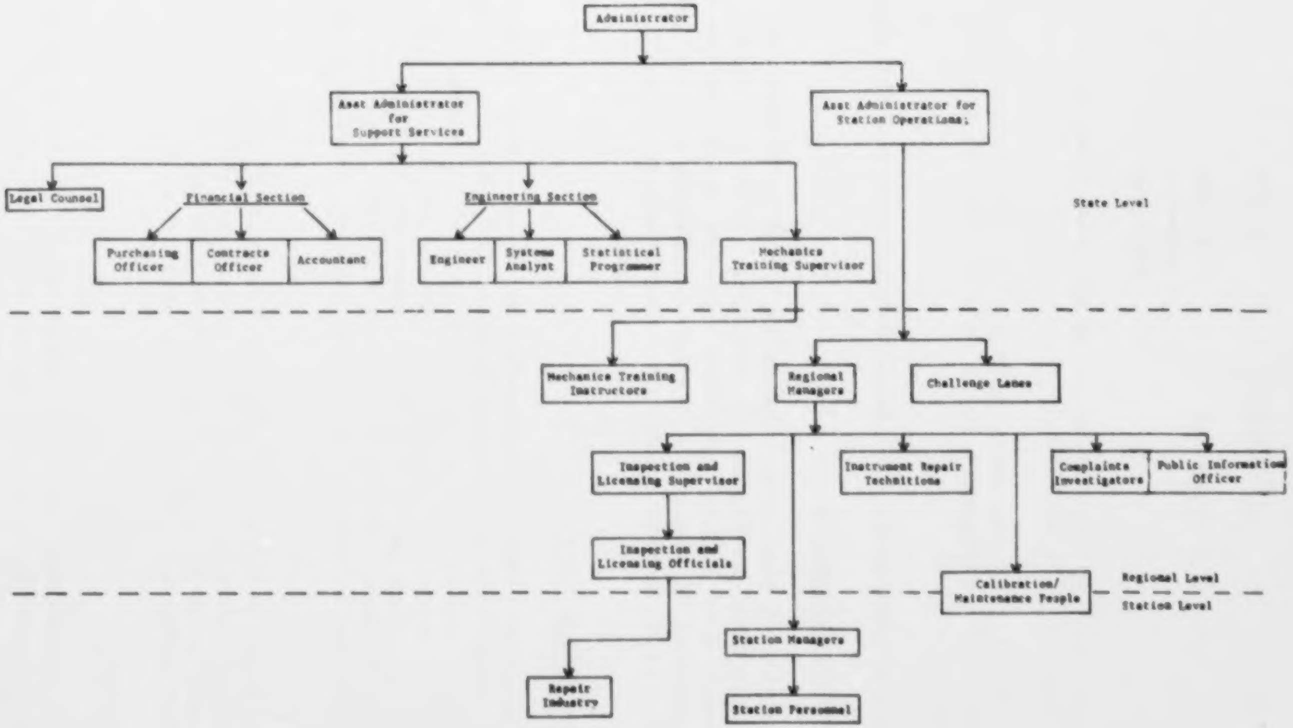
Administrator
Asst Administrator for Support Services
Asst Administrator for Station Operations;
Legal Counsel
Financial Section
Purchasing Officer
Contracts Officer
Accountant
Engineering Section
Engineer
Systems Analyst
Statistical Programmer
Mechanics Training Supervisor
State Level
Mechanics Training Instructors
Regional Managers
Challenge Lanes
Inspection and Licensing Supervisor
Instrument Repair Technitions
Complaints Investigators
Public Information Officer
Inspection and Licensing Officials
Calibration/ Maintenance People
Regional Level
Station Level
Repair Industry
Station Managers
Station Personnel

Figure 8. State manpower requirements.

TABLE 98. STATE MANPOWER REQUIREMENTS

Number of positions	Title	Annual salary	Total cost
1	Administrator	$25,000	$25,000
1	Assistant Administrator for S.S.	17,000	17,000
1	Assistant Administrator for Sta. Ops.	21,000	21,000
1	Legal Counsel	15,000	15,000
1	Purchasing Officer	13,000	13,000
1	Contracts Officer	13,000	13,000
1	Accountant	12,000	12,000
1	Engineer	10,400	10,400
1	Systems Analyst	11,000	11,000
1	Statistician Programmer	10,500	10,500
1	Mechanics Training Coordinator	13,000	13,000
3	Regional Managers	21,500	64,500
3	Regional Inspection and Licensing Supervisors	15,500	46,500
3	Regional Complaints Investigators	15,500	46,500
3	Regional P.R. Coordinators	15,500	46,500
5	Mechanics Training Program Instructors	11,000	55,000
6-17	Mobile State Garage Inspectors	15,500	93,000- 263,500
10	Secretary/Typists	8,000	80,000
5	Clerks	7,000	35,000
1	Referee Lane Supervisor	20,000	20,000
2	Referee Lane Inspectors	10,400	20,800
1	Referee Lane Maintenance/Calibration	12,000	12,000
	Total		$680,700-$851,200

TABLE 99. SYSTEM COSTS, PRIVATE GARAGE OPTION

	Minimum network ($)	Maximum network ($)
CAPITAL EXPENDITURES		
Inspection vans	84,000	238,000
Referee lane	155,203	155,203
Software	20,000	20,000
RECURRING EXPENDITURES		
Salaries	695,340	864,740
Equipment replacement	20,000	50,000
TOTAL COST TO STATE	974,543	1,327,943
Number of private garages	394	1,130
Estimate of total private garage expense (dollars)	6,999,804	11,789,290

Break-even Fees

Based on 394 garages paying a licensing fee of $100 each, the state must raise $935,143 from fees each year to cover program costs.[5] Spread over the 1987 expected inspection figure of 2,054,480 inspections, each inspection must yield a net revenue to the state of $0.46. The private garage earns $4.50 per inspection. This results in a total vehicle inspection fee of $4.96 for the minimum network private garage option.

Looking at the maximum network, a break-even fee of $5.09 must be charged to cover all state costs.[6] In addition to the $4.50 the private garage earns, this represents a $0.59 charge per inspection to cover $1,214,943 in state expenses that exceed the total funds collected from license fees for 1,130 inspection sites.

FOOTNOTES FOR SECTION 9

1. Based on the following assumptions:

   1) all reinspections of failed vehicles are performed at private garages

   2) 1 day = 8 hours

   3) 1 year = 250 days

   4) minimum test time = 15 minutes

   5) private garages are 67 percent efficient (to account for random arrival, equipment downtime, etc.)

   $$N = \frac{8 \text{ hours} \times 60 \text{ minutes}}{15 \text{ minutes}} \times 250 \text{ days} \times 0.67 = 5{,}250$$

   Note: this calculation rounds daily throughput down to 21

2. This figure is calculated using the modified TR = TC equality:

   $$M\,(C - F) = A + S + L + O$$

   It assumes that (C - F), the fee received by an inspection station is $4.50

   $$M\,(4.50) = 751.88 + (4)(5.50)(250) + \frac{(4)(5.50)(250)}{3}$$

   $$M = 1{,}819$$

3. Total private garage expense, minimum network, 1987

   From discussion above, total costs =

   $$TC = A + S + L + O$$

   where: A = cost of analyzer = $3,000

   S = mechanic salary = (250)(8)($5.50)

   = $11,000 per year

   L = licensing fees = $100

   O = overhead = 1/3 (11,000) = $3,666

For one station,

TC = (3,000) + (11,000) + (100) + (3,666)

= $17,766

For the minimum network of 394 stations, the total expense =

(394) ($17,766) = $6,999,804

4. Total private garage expense, maximum private garage network, 1987

From discussion above, total costs =

TC = A + S + L + O

where: A = cost of analyzer = $3,000
S = mechanic salary = (250)(4)($5.50)
= $5,500
L = licensing fees = $100
O = station overhead = 1/3 ($5,500)
= $1,833

For one station,

TC = (3,000) + (5,500) + (100) + (1,833)
= $10,433

For the maximum network of 1,130 stations, the total expense =

(1,130) ($10,433) = $11,789,290

5. Break-even state charge, minimum private garage network, 1987

Assume each private garage in the network pays a $100 license fee per year. Then total license revenue =

(394) ($100) = $39,400

Subtracting this license revenue from total costs yields the amount of revenue to be raised through inspection charges to private motorists:

$974,543 - $39,400 = $935,143

Dividing this revenue by the number of inspections to be performed yields the break-even state charge per inspection:

$$\frac{\$\ 935{,}143}{2{,}054{,}480} = \$0.4551$$

Based on our previous assumption of a $4.50 garage charge, the inspection would cost a private motorist $4.50 + $0.46 = $4.96.

6. Break-even state charge, maximum private garage network, 1987

Assume each private garage in the network pays a $100 license fee to the state each year. Then total license revenue =

$$(1{,}130)\ (\$100) = \$113{,}000 \text{ per year}$$

Subtracting this license revenue from total costs yields the amount of revenue to be raised through inspection charges to private motorists:

$$\$1{,}327{,}943 - \$113{,}000 = \$1{,}214{,}943$$

Dividing this revenue by the number of inspections to be performed yields the break-even inspection charge:

$$\frac{\$1{,}214{,}943}{2{,}054{,}480} = \$0.5914$$

Based on our previous assumption of a $4.50 garage charge, the inspection would cost a private motorist $4.50 + $0.59 = $5.09.

SECTION 10

POSSIBLE I/M PROGRAM EXTERNALITIES

INTRODUCTION

The subject of externalities arising from an I/M program is quite complex. To provide a complete picture of the program there are indirect, as well as direct, impacts that should be considered. The issues raised by these potential externalities are extremely difficult to quantify. Many of these costs and benefits are qualitative and, as such, highly subjective. Also, much of the data that is available pertaining to these issues is either incomplete or inconclusive. In light of the problems inherent in these issues, attempts to completely quantify them would obfuscate matters rather than provide useful information. In consideration of this the discussion that follows is fairly general and primarily qualitative in nature. It is intended to identify some of the pertinent issues and the likely direction, if not the magnitudes, of various impacts.

I/M is designed to achieve a reduction in motor vehicle emissions levels. All other effects the program has are considered secondary or indirect. This section opens with a general discussion of these secondary impacts. General impacts on the vehicle user population and the repair industry are also noted. Some of the impacts of program implementation that are dealt with in this section are:

- Health benefits
- Impact on vehicle performance and vehicle life
- Impact of required maintenance costs
- Time costs of traveling to and from the inspection site
- Impact on repair industry employment

GENERAL EXTERNALITIES

General Impacts

There are a number of positive externalities that are likely to accrue to society at large from a successfully implemented I/M program. Improving ambient air quality should create significant health benefits. A reduction in respiratory related medical problems is likely. This will, in turn, lead to a series of secondary or indirect effects. If the general population becomes healthier, fewer days of production will be lost due to illness. Industry costs for sick leave pay will decline as a result. The average longevity of the population should also increase slightly. This change should help ease the workload of medical personnel who are in short supply, freeing them to turn their attention to other pressing needs.

To date a substantial investment has been made in pollution control equipment on automobiles. This investment will continue to grow as new cars equipped with control devices are produced to replace older vehicles lacking them. Emission control systems deteriorate steadily in efficiency with use unless they are periodically maintained. If unchecked, this deterioration can completely eliminate the benefits of installing the systems to begin with. As there are no user observable signs of this deterioration or incentives to correct it were it known, the necessary maintenance is likely to remain undone. Thus an I/M program can have a major impact by insuring the integrity of these control devices. In addition to protecting a projected nationwide investment of $150 billion by 1980[1] benefits accruing from foregone pollution costs may run to several billions of dollars per year, nationwide.

Should a vehicle safety inspection program be implemented in conjunction with an I/M program, substantial operating economies are possible. Combining these two programs in one facility can avoid duplication of personnel and fixed costs. Overhead can be shared, land requirements for a combined set-up would be less than separate facilities require, etc. The incremental cost of adding safety inspections to an I/M network would be lower than the cost of establishing it independently. One private contractor estimates that the addition of safety inspections to a fully operational loaded mode emissions testing facility would increase costs by roughly 20 to 30 percent. This estimate assumes the I/M facility has been designed with this expansion in mind.

Impact on Vehicle Performance and Vehicle Life

The impact of I/M on these considerations is difficult to quantify. The studies to date have not been conclusive. They have centered on the way I/M affects short and long run vehicle deterioration curves. The short run deterioration curve reflects the rate at which a vehicle deteriorates after it has been tuned while the long run curve reflects the overall degradation in vehicle performance that occurs as it ages. Both curves, especially the short run deterioration curve, influence vehicle performance while the slope of the long run curve is the primary determinant of vehicle longevity.

A study of Colorado's I/M program indicates that after a vehicle is repaired under that program it deteriorates to a prerepair condition in as little as 6 months.[2] This result is likely to be atypical though since Colorado's program is carried out at high altitude where engine adjustments required to yield acceptable vehicle performance necessitate frequent tuneups. Another study, under more typical conditions, set the short run deterioration rate low enough so repaired vehicles remain above their prerepair level over a yearly inspection interval.[3]

To the extent that I/M influences the short run curve it should have a positive impact on vehicle performance. If an engine stays closer to manufacturer's specifications it should perform at a higher level due to I/M.

The influence on performance and longevity resulting from I/M's impact on the long run deterioration curve is unknown now. No I/M program has been in effect long enough to draw definitive conclusions on this issue. As time goes by and the history of these programs lengthens, the relationship between I/M and the long run deterioration curve for vehicles will become clear and better inferences on its effect on vehicle life and performance can be drawn.

Impacts on Vehicle Owners

While energy conservation may well turn out to be a tangible benefit in the large sense, its impact on the individual vehicle owner is somewhat nebulous. He perceives fuel savings as an economic issue, not as a conservation concern. That is, how much will his operating costs be reduced by the increased efficiency he experiences in upgrading his vehicle's maintenance level to meet I/M standards. Most estimates indicate that the fuel savings resulting from I/M are negated in a monetary sense by the costs of attaining them.

This argument overstates the maintenance cost disadvantage to a degree. While it is true that a vehicle owner is forced to make a repair if his vehicle doesn't comply, it is inaccurate to charge the entire cost of mandated repairs to I/M requirements. I/M will cause vehicles to be repaired more completely and frequently than they would be without it. Indeed, this is the purpose of I/M. But, a fraction of the repair cost would have been incurred anyway. While an estimate of what fraction is induced by I/M (estimates vary from 25 to 75 percent) is open to debate regarding it's magnitude, the general principle holds.

This issue of mandated repairs is central to I/M program externalities. The cost of these repairs is a burden on the vehicle owner. These costs won't be distributed evenly throughout the population. It is safe to assume that older vehicles are more likely to be out of compliance than newer vehicles which are generally more completely maintained and equipped with control devices. These older vehicles will generally be owned by individuals at the lower end of the socio-economic spectrum. Coupled with the larger and more frequently required repairs on older vehicles, this fact illustrates the regressive nature of the burden I/M compliance requirements places on society. This uneven impact partially is mitigated by establishing exemptions to compliance based on vehicle age and ceilings on the dollar value of mandated repairs.

As the vehicle mix changes over time this problem will become less severe than it is now. As older vehicles, those that are costly to maintain to standards, drop out of the vehicle population they will be replaced by used vehicles that are more likely to have been well maintained and hopefully less costly to maintain throughout their serviceable life.

This trend will be countered to a certain extent because vehicles filtering down via resale will be equipped with various emission control devices. This equipment and the catalytic converter in particular will require major servicing and replacement as vehicles age. This replacement cost will not occur until an equipped vehicle is several years old. By that time the vehicle has most likely changed hands, placing the burden of control device replacement on the used car buyer who is generally in a lower income category than is the initial purchaser. This postponement of replacement cost is reinforced by federal warranty provisions which stipulate that a vehicle manufacturer is responsible for replacing properly maintained control devices that have failed during the first 50,000 miles of vehicle use.

The increased purchase price of vehicles due to the inclusion of costly control devices in it's manufacture is likely to increase vehicle prices in the resale market. Adding this to the potential control device burden during the later years of vehicle life results in a significant redistributional impact of I/M that is highly regressive in nature.

Establishing an accurate average cost for repairs that are induced by I/M is difficult. General data from existing programs can provide a starting point in contemplating the magnitude of this figure. For California's Riverside Trial Program the average repair cost for a vehicle failing inspection, including parts, tax and labor was $16.96.[4] This figure includes extra repairs completed in addition to those recommended of $10.90 and $9.30 for idle mode and $10.20 and $9.40 for key mode testing in each respective state.[5] These figures apply repair costs for a 40 percent stringency rate over the entire fleet population tested, underestimating the actual cost per vehicle repaired. Average repair values for California were $27.33 and $32.08 for idle and key modes. For Michigan these figures were $23.29 and $36.56.

In both these and other studies the repair costs calculated as resulting from I/M will be underestimated. Repair cost figures are collected for vehicles that have failed inspection and received repairs as a result of that failure. No accounting is made, nor can it be made with current data, of extra repair costs incurred in anticipation of inspection. It is likely that some vehicles that pass the first time through inspection have attained higher maintenance standards than they would have otherwise in order to avert failure and the inconvenience of travelling to the inspection site a second time for retesting. Until a study is designed to uncover these costs they will continue to remain elusive.

The nature of repairs required to meet I/M standards for failed vehicles can help shed light on the burden noncomplying vehicle owners must bear. The Riverside Trial Program found that 66 percent of the diagnosed repair evaluations consisted of an imbalance in the idle air-to-fuel ratio. An additional 18 percent of vehicles failing were diagnosed as experiencing rich carburetion. These problems are not difficult or costly to rectify. Thus the average repair cost figures are probably misleading. Most vehicles requiring service will experience costs lower than the average reported figure. A small portion will have bills considerably in excess of the average. If these large bills fall into waiver regions (either an absolute dollar limit on repair cost or a percentage of vehicle value figure) then assuming an average repair cost for all failed vehicles can overstate the total repair cost burden to vehicle owners.

There are other costs to vehicle owners relating to I/M in addition to repair costs and the actual inspection fee. Two major costs to consider are time and operating costs experienced travelling to and from inspection sites. Actual operating costs can be calculated fairly accurately. Time costs have a much more subjective nature.

The vehicle miles travelled (VMT) as a result of an I/M program depend on the size of the affected vehicle population, density of that population, siting of inspection stations and so forth. A fairly reliable total VMT estimate can be used to determine total vehicle operating costs and time spend on those induced VMTs. Applying an average emission level to these extra VMTs can provide a rough estimate of emissions induced by the implementation of I/M.

An elusive but probably more significant figure is the time cost of travel to and from, and waiting time at inspection facilities. There are evaluative decisions about the value of time spent travelling, waiting time and so on that must be resolved before a dollar figure can be computed. The issue is complicated because different people value their time differently and even value different types of time differently (e.g., time spent driving versus time spent waiting at an inspection site). The value an individual places on his time is related to his income level. As income rises an individual tends to value his time more highly.

Estimating operating and time costs is further complicated because it is difficult to determine what portion of these costs to assign directly to I/M requirements. Many times the trip to an inspection site is combined with other errands and stops. The total costs, time and operating, of such trips should be allocated between the different purposes served by them. It is also difficult to determine how circuitous the I/M stop is. It may require a substantial detour in some cases and none in others.

A potential benefit for the vehicle owner is money saved by utilizing diagnostic information provided by I/M (especially for loaded mode testing) to correct small problems before they become serious. By prompting repairs now I/M can help eliminate substantial costs to the vehicle owner.

This brief overview of the impacts I/M may have for vehicle owners serves to emphasize the elusive nature of program costs and benefits. A qualitative evaluation of them helps assure that they will be considered when implementing I/M.

Impacts on the Automotive Repair and Parts Industry

It is safe to state that I/M implementation will result in an increased demand for repair activities and replacement parts. To the extent that I/M induces new repairs that would not have been performed otherwise the repair industry will directly benefit from the program.

Job creation will be necessary to increase the supply of repair personnel to meet new demand. The ratio of mechanics to vehicles has been declining significantly over the last few decades. In 1950 there were 73 vehicles for every mechanic nationwide. By 1975 this ratio shifted, with one mechanic available for every 146 vehicles. This trend cannot continue if I/M becomes a reality. As emissions regulations increase vehicle complexity and extend repair times for existing components as well as creating new subsystems that will eventually require repairing, the demand for mechanic time will increase for each vehicle.

In addition to recruiting and training new mechanics, existing personnel should undergo at least a limited retraining phase to orient them to the purposes and goals of I/M and emissions control. In some cases the needs of I/M are in conflict with maintenance standards now existing that emphasize engine performance. It is important that the repair industry is aware of the different criteria demanded by I/M and acts accordingly.

No matter how responsive the supply of mechanics is to this increase in demand some lag is inevitable. Because of this, windfall profits are likely to accrue to existing members of the industry for a time at least. The tight supply situation could result in some overcharging and unnecessary repair work. This should only be transitory as new mechanics are trained and enter the labor pool and the public becomes aware of the implications of I/M. Also, a well supervised maintenance sequence should help deter potentially disruptive behavior by the repair industry.

Impact of Test Type

The choice of a loaded mode option would result in certain benefits that would not be present with idle mode testing. These benefits are of two general types. First, the loaded mode alternative has the capability of measuring oxides of nitrogen. This pollutant is not emitted in measurable quantities unless an engine is under load conditions. Idle mode tests are not able to measure it at all. There are only a small number of areas in the country that are not in compliance with NO_x standards. Thus, this capability is useful in certain areas but for most areas this potential will remain unrealized.

A second benefit that loaded mode testing provides is additional diagnostic information for each vehicle inspected. When utilized correctly, this information can help pinpoint problems early and accurately. This should increase the benefits resulting from repair work and lower the incidence of unnecessarily (knowingly and unknowingly) performed repair work.

The value of this improved diagnostic information is dependent on the ability of the repair industry to accurately interpret it. There has been speculation that currently the repair industry would have difficulty utilizing this data. The information needed to correctly analyze these test results is not extensive. It is entirely feasible to supply this information along with the test results to insure that it finds its way into the hands of mechanics who can utilize it. Since the interpretation required is not complex, once mechanics have been exposed to it they will be able to use it as another tool on a daily basis.

These benefits are not cost-free. Traded off against them are equipment costs that are larger than idle mode costs and higher utility costs (principally for the dynamometer required); implying that loaded mode testing will increase overall operating costs.

It would be ideal if the benefits peculiar to loaded mode testing and the added diagnostic information in particular could be quantified and compared to the added costs associated with it. Statements about the cost differential between test mode types can be made with fair certainty. Unfortunately the same can not be said for the benefits side of the issue. There hasn't been a program of sufficient duration yet that is designed to collect the information needed to quantify these benefits. Beyond subjective exposition on the likely nature of them, little can be said about their likely magnitude.

The actual cost of inspection to the vehicle owner will be higher for loaded testing than it would be for idle mode operations. Depending on public reaction to program costs this could create an unfavorable political climate for more expensive options.

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SECTION 11

LEGISLATIVE CONSIDERATIONS IN I/M IMPLEMENTATION

Legislative requirements and potential roadblocks that are not applicable to all options, but which could adversely affect implementation of one or several options, were researched for the Wisconsin inspection/maintenance options. The reason for looking at these potential problem areas is to determine, at an early planning/evaluation stage, if there are any legal, legislative or other issues related to any option under consideration which potentially would hinder its acceptance by the state legislature.

METHODOLOGY

The methodology to research this problem consisted of two stages. In the first stage the options themselves were studied in detail to determine what legal, organizational, or institutional problems, conflicts, or implications there were, if any. Also, model legislation for inspection/maintenance programs provided by U.S. EPA was studied. U.S. EPA was also consulted to determine if they had uncovered problem areas which should be further researched. The second phase consisted of studies of other states' inspection/maintenance programs. Directors and staff members were asked to comment on particular problems they had encountered, and the state enabling legislation was studied.

Because the State of Wisconsin has itself not involved the legislature in this early planning phase, and would not be able to provide appropriate comments on the options, they were not contacted. At a later stage in the development of the I/M program, the legislature will become more directly involved and will presumably draft enabling legislation that minimizes potential problem areas.

POTENTIAL LEGAL ISSUES

There are no intrinsic problems with the options themselves in terms of purely legal issues. Whether the State decides on a contractor centralized approach, a decentralized private approach, or State-run centralized lanes does not matter from a legal framework. Nor are there any legal grounds that would hinder combining emissions testing with safety and noise testing. Federal law requires states to have at least pilot programs for periodic motor vehicle safety inspection. However, there is no current federal law governing in-use vehicles for noise inspection. Federal standards have been set for safety and noise for vehicles being manufactured. The lack of federal legislation for noise, however, does not prohibit the state from exercising its constitutional police power to regulate the health, safety, and morals of its citizens. Consequently, the state using its police power may legally pass appropriate legislation and set standards for both motor vehicle safety and noise for in-use vehicles.

LEGISLATIVE AND OTHER POTENTIAL ROADBLOCKS

There are other considerations that are not directly in conflict with legal requirements that may affect the prospects of certain options passing successfully through the legislative process. While not strictly of a legal nature, these considerations are worth keeping in mind when analyzing the legislative feasibility of different options.

Some options may encounter licensing problems, especially the private garage and contractor approaches. Both are subject to EPA licensing requirements that do not affect the state approach. An EPA-approved training and certification program for mechanics must be established by the state for these two approaches. A private garage must have a licensed mechanic present in order to be certified as an I/M inspection station. Facilities operated by private contractors must also have certified personnel on hand.

At this point, EPA officials have declined to elaborate on licensing requirements and procedures pending the release of a position paper (due in July) that will deal explicitly with these issues. The licensing procedure should consist of similar requirements for the nongovernment options, contractor and private garage. There should be no problem from the state viewpoint regarding a licensing procedure of the type the EPA is contemplating.

The private garage approach incurs higher administrative costs because more facilities must be licensed and federally-required monthly inspections of equipment in those facilities will be more costly than for centralized I/M lanes.

While licensing requirements reduce the attractiveness of private approaches, tax considerations favor them over state-operated facilities. From a municipal point of view, the contractor approach is most favorable while a state-run facility is least favorable. If the latter approach is chosen, the land on which inspection facilities are sited would be purchased by the state, removing it from municipal property tax rolls. While this is technically a transfer from the municipality to the state and not a cost or benefit, it is a real loss in funds to the municipality. This fact may generate opposition from the affected municipalities.

Options that call for state-run facilities will demand a large personnel commitment. This could prove unpopular, resulting in implementation difficulties. Adding a significant number of employees to the state payroll will incur a large expense that will be difficult to reduce in the future. In fact, future pension requirements are not likely to be fully covered by inspection fees, possibly leading to an ongoing deficit problem.

Regarding personnel policies, more flexibility exists with the private approaches. If program manpower requirements change, a contractor will be able to respond more rapidly and with fewer political pressures than the state could.

A final consideration that may have option-specific implications is the different types of funding required for various options. The availability of funding for capital costs versus operating and administrative costs may have a significant impact on the probability of implementing certain options. Consideration may be given to leasing state facilities to contractors or leasing private facilities for state use to ameliorate adverse effects that funding problems may cause.

CONCLUDING REMARKS

In large part, legislative problems are likely to be political in origin. There are no purely legal federal or state roadblocks to any of the options presented. Rather, the nonlegal ramifications of the various options are more pertinent.

While it would be ideal if all potential problems could be anticipated when enacting I/M legislation, it is unlikely that all such difficulties will be taken into account. The enabling legislation should be flexible enough to allow a degree of discretion for the administrative agencies involved. Leeway on quality controls, cut points, etc. should improve program effectiveness considerably. Building such discretion into regulatory authority should shorten lead times and prove cost effective as well as flexible.

SECTION 12

PUBLIC INFORMATION PROGRAMS

Experiences in several states that recently established inspection/maintenance programs emphasize the importance of an effective public information program. A well-designed, comprehensive program that introduces the public to the basic need for and benefits of I/M and clarifies the misunderstandings that surround I/M is critical during the early stages of implementation. A well thought-out program can help eliminate potentially adverse reactions that other states with inadequate public information programs experienced (e.g., Arizona, Cincinnati, Ohio, and Chicago).

METHODOLOGY

To estimate the costs of public information programs all states with experience in I/M public information programs were contacted. Included were states with currently operational programs and those just beginning the early planning stages. The U.S. EPA was consulted to determine basic program elements and a literature search was conducted. From contacts and research a full range of possible activities was established and basic cost figures derived. It is important to note, as will be explained later in this section, that the range of possible activities and comprehensiveness of public information programs varies considerably. Therefore, broad assumptions concerning the range of public information activities that Wisconsin will conduct must be made to present potential cost figures. These assumptions will be defined in the following sections.

INITIAL PUBLIC RELATIONS PROGRAMS

The initial public information program may be conducted from several months to over a year prior to the actual beginning of mandatory inspection and maintenance. The range of activities among the various programs has varied considerably depending on the particularities of each state. The U.S. Environmental Protection Agency has recently made grants available for I/M public relations work through their regional offices. These grants have generally been $15,000, although this is subject to the total amount made available by Congress in appropriating the funds. U.S. EPA cannot commit itself now to the exact amount that will be available in the future due to the uncertainties in appropriations. As examples of the types of programs utilizing these funds, both Rhode Island and Massachusetts are currently establishing public information programs with these $15,000 grants. Rhode Island is in the first year of a mandatory inspection and voluntary maintenance program. It is the first state to implement a private, decentralized garage approach. Massachusetts, as yet undecided as to which type of program to implement, is also utilizing these funds. In both states the local lung association, a voluntary nonprofit citizens group presenting clean air programs and disseminating information on health and clean air, has been given the job of organizing the public information program. Massachusetts' program involves several elements including a slide show for presentation to civic and other groups. A mobile van with an emission analyzer plus an informational display is being taken to major shopping centers and other key activity centers around the state. Automobile oriented groups including automobile associations are being contacted in order to solicit their support. Also, brochures are being prepared for mass circulation to citizens and motorists. These program elements are typical of the activities conducted early in the planning or implementation stage.

Similarly, Portland, Oregon has utilized mobile vans with emission analyzers. Oregon found that bumper stickers (at $0.10 to $0.15 each) were one of the most successful public information tactics. Another tactic commonly used in such campaigns was to depict an important public official such as the governor having his car inspected on television. It should be noted here that some tactics, while successful in one area, would not be particularly useful in other states.

In New Jersey, posters were circulated in large volumes around the state. Each new car dealer and garage that purchased an emission analyzer was contacted and the state compiled lists of approved analyzers. The dealers and garages displayed signs indicating they had the analyzer. This was an important public information program element.

Two program elements stand out as being widely used as I/M public information techniques. One is the use of radio and television spot announcements and newspaper advertisements. A second technique that is key to reaching the individual motorist is preparing an informational pamphlet and mailing it to all vehicle owners, usually along with motor vehicle registration forms to save extra mailing costs.

In relating these program elements to the specific options, the most useful cost figure is a per vehicle cost of $0.12; both California and Arizona have indicated costs in this range. Basically these costs cover pamphlet preparation and distribution costs (to each motorist) and mass media announcements. In Wisconsin, given that neither the geographical coverage nor the number of vehicles varies among the options, this cost calculation would remain the same for all options. At a later stage in implementation, Wisconsin may design a public information program with elements specified to a degree that will allow costs to be more closely estimated.

ONGOING PUBLIC RELATIONS

The ongoing public information program costs and elements are not as variable as the initial program elements. The major elements found in other state's programs are the same elements described above for the basic initial costs; a pamphlet mailed to each motorist and periodic mass media coverage, usually spot announcements and newspaper advertisements. Consequently, the annual cost of the ongoing public information program is estimated by multiplying the number of vehicles times $0.12.

SECTION 13

COMPARISON OF OPTIONS

COMPARISON OF OPTIONS

Emission Reductions

The amounts of emission reductions attributable to an I/M program are a function of stringency level, mechanic's training, the geographic coverage, the vehicle population, and the travel characteristics of the affected areas. Since these factors are constant across all six I/M program options considered here, the emission reductions are considered the same for each option. Emission reductions are summarized in Table 100. However, there would conceivably be some minor differences among the options. For example, it is generally accepted that quality control of private garages makes uniformity of inspection somewhat less than for centralized facilities. If fewer cars were failing the emissions test or cars were being passed that actually exceeded the standards, then presumably the emission reductions would be somewhat less in private garages. Having a well-run quality control and mechanics/inspection training program should offset such lack of uniformity. Also, the test type would result in some difference in emissions. An idle test without a high idle purge during hot weather creates unusally high emission readings. With high idle purge, the idle test is approximately as accurate as the basic loaded-mode test. Again, such variations cannot readily be predicted but may influence the emission reductions.

Fuel Savings

The factors which influence total fuel savings are the percent increase in fuel economy, and the total vehicle miles traveled (VMT), and the stringency factor. Since these factors are the same across all options, the fuel savings is considered equal for each of the six options. As was the case for emission reductions, however, there may be some minor variation among the options. Centralized lane approaches, state or contractor-operated will generally have a higher level of quality control and greater uniformity of inspection. They may result in a somewhat better improvement in fuel economy, although this would be difficult to estimate. Again, the loaded-mode test being somewhat more accurate than the idle-mode, especially if a high idle purge is included, may bring about better overall fuel savings.

TABLE 100. EMISSION REDUCTIONS - 1000 gm/day[a]

	Hydrocarbons					Carbon monoxide				
	1977	1987 without I/M[†]	1987 I/M[‡]	Percent reduction 1977-1987 I/M[‡]	Percent reduction 1987[†]-1987 I/M[‡]	1977	1987 without I/M[†]	1987 I/M[‡]	Percent reduction 1977-1987 I/M[‡]	Percent reduction 1987[†]-1987 I/M[‡]
Milwaukee - 7 County Metro Area										
Kenosha Co. Freeway & Arterials	9,176	3,500	2,664	71	24	64,663	33,918	23,621	64	30
Milwaukee Co. F&A	70,552	23,031	17,519	75	24	445,290	242,761	175,906	61	28
Ozaukee Co. F&A	5,012	1,916	1,472	71	23	35,460	19,332	13,706	61	29
Racine Co. F&A	12,011	4,226	3,222	73	24	88,172	42,946	30,559	65	29
Walworth Co. F&A	5,910	2,359	1,877	68	20	42,018	25,551	19,485	54	24
Washington Co. F&A	6,622	2,454	1,944	71	21	45,405	25,803	19,455	57	25
Waukesha Co. F&A	21,726	8,150	6,389	71	22	159,339	90,466	68,999	57	24
7 County Local	20,502	6,861	5,264	74	23	175,198	69,895	50,166	71	28
Aggregate	151,571	52,497	40,356	73	23	1,055,545	550,672	401,897	62	27
Brown County										
Aggregate	-	6,170	4,685	-	24	-	61,718	435,461	-	29
Dane County										
Aggregate	-	10,310	7,838	-	24	-	102,948	73,343	-	29

[*] Does not reflect reductions from light duty trucks

[†] Reflects only changes in VMT and the effects of the Federal Motor Vehicle Emissions Control Program (FMVECP)

[‡] Reflects changes in VMT, effects of FMVECP, and the impact of I/M

Costs

The major cost components of Options 1 through 5 are summarized in Tables 101 and 102. All these options involve centralized facilities run either by the state (Options 4 and 5) or a contractor (Options 1, 2 and 3). Options 1 and 4 are loaded inspection combined with safety, Option 2 is a loaded inspection only, and Options 3 and 5 are idle inspection only.

The major cost differences occur between options involving different inspection modes. Loaded inspection is approximately 50 percent more expensive than idle inspection, and adding safety inspection increases cost another 50 percent. Government run facilities are 2.5 percent more expensive than contractor-run facilities for idle inspection, and 1 percent more expensive for loaded safety inspection. The difference between the state and contractor approach is in the area of startup costs where the state is bound by restrictive bidding procedures. Potential cost difference may also occur in wage rates which were assumed to be identical in this report.

Fees per paid inspection are also given in Tables 101 and 102. The f_c fee is a uniform fee in constant dollars and increases with inflation, while the f_a fee is uniform in actual dollars. These fees are designed to recoup state as well as contractor costs for all options.

The costs of Option 6, private garage inspections, are reported in Table 103. These costs consist of two components, the private garage costs and state administrative costs. The state administrative costs range from $0.46 to $0.59 per inspection. The costs to the garage depend upon the number of inspections performed yearly. For 20 percent of the private garages providing inspections, the average garage would have volume sufficient to charge a dollar fee of $1.57 per inspection. As increased numbers of garages provide inspections, average inspections per garage decrease and costs increase to $7.84 per inspection with 100 percent participation.

Care should be taken in comparing the costs of Options 1 through 5 with the costs of Option 6. The breakeven costs reported for Option 6 are for each inspection, while the fees for Options 1 through 5 are for each paid inspection. Since Options 1 through 5 include a free reinspection for failed vehicles, there are 1,470,000 paid inspections compared to 1,911,000 actual inspections.

Manpower Requirements

Manpower requirements vary among options reflecting differences in inspection activity and/or administrative requirements. The specific requirements for each option are shown in Table 104, by two categories - adminsitrative personnel and operations personnel.

From Table 104 it can be seen that the administrative personnel requirements are fairly constant across all six options, while the operations personnel requirements vary substantially. Administrative personnel would be entirely state employees while the operations personnel would be employed either by the state (in Options 4, 5, and 6) or a contractor (Options 1, 2, and 3).

TABLE 101. ANNUAL COST OF OPTIONS AND FEES WITH $i = 0.03$.
(ALL FIGURES ARE 1978 DOLLARS)

Option	I	II	III	IV	V
I. Annualized capital costs					
1. Land	110,747	39,375	35,230	110,747	35,230
2. Buildings	658,509	233,688	206,821	658,509	206,821
3. Equipment	2,151,557	809,281	614,250	2,151,557	614,250
II. Annualized start-up costs	760,177	537,186	521,351	870,296	631,479
III. Annual operating costs	8,912,152	3,962,268	3,778,983	8,077,452	3,599,688
IV. Annual administrative cost	684,810	684,474	664,586	684,810	684,474
Total annual costs	13,277,952	6,266,542	5,841,109	12,553,340	5,771,942
(f_c)	7.481	3.279	3.291	7.072	3.252
(f_a)	9.408	4.089	4.146	9.416	4.129

f_c = uniform fee in constant dollars.

f_a = uniform fee in actual dollars.

TABLE 102. ANNUAL COST OF OPTIONS AND FEES (WITH $i = 0.06$).
(ALL FIGURES ARE 1978 DOLLARS)

Option	I	II	III	IV	V
I. Annualized capital costs					
1. Land	221,493	78,751	70,459	221,493	70,459
2. Buildings	855,080	303,445	268,558	885,080	
3. Equipment	2,338,734	879,686	667,687	2,338,734	667,687
II. Annualized start-up costs	826,309	583,920	566,707	946,008	686,416
III. Annual operating costs	8,912,152	3,962,268	3,778,983	8,077,452	3,599,688
IV. Annual administrative cost	684,810	684,474	664,586	684,810	684,474
Total annual costs	13,838,578	6,492,814	6,016,980	13,123,577	5,977,282
(f_c)	7.796	3.398	3.390	7.394	3.367
(f_a)	9.732	4.188	4.265	9.744	4.233

f_c = uniform fee in constant dollars.

f_a = uniform fee in actual dollars.

TABLE 103. OPTION 6 COSTS

Market Participation	Private Garage Breakeven Charge
0.20	1.57
0.30	2.36
0.40	3.14
0.50	3.93
0.60	4.72
0.70	5.49
0.80	6.27
0.90	7.06
1.00	7.84

TABLE 104. SUMMARY OF PERSONNEL REQUIREMENTS

Title	Annual salary	Number of positions for each option					
		Option 1	Option 2	Option 3	Option 4	Option 5	Option 6
Administrative							
Administrator	$25,000	1	1	1	1	1	1
Assistant Administrator (Support)	17,000	1	1	1	1	1	1
Assistant Administrator (Operations)	21,000	1	1	1	1	1	1
Legal Council	15,000	1	1	1	1	1	1
Purchasing/Contracts Officer	13,000	2	2	2	2	2	2
Accountant	12,000	1	1	1	1	1	1
Engineer	10,400	1	1	1	1	1	1
Systems Analyst	11,000	1	1	1	1	1	1
Statistician/Programmer	10,500	1	1	1	1	1	1
Mechanic Training Coordinator	13,000	1	1	1	1	1	1
Regional Manager	21,500	3	3	3	3	3	3
Regional Inspector	15,500	6	6	6	6	6	6
Regional Public Information Coordinator	15,500	3	3	3	3	3	3
Mechanic Training Instructor	11,000	1	1	1	1	1	5
Instrument Repair Technician	12,000	1	1	1	1	1	-
Inspector/Licensing Officer	15,500	1	1	1	1	1	6-17
Clerk	7,000	-	-	-	-	-	5
Typist/Secretary	8,000	-	-	-	-	-	10
Operations							
Manager	20,000	20	20	15	20	15	1
Assistant Manager	13,500	20	20	15	20	15	-
Maintenance Persons	12,000	9	7	5	9	5	1
Inspectors	10,400	344	216	141	344	141	2
Total Personnel		419	289	202	419	176	53-64

APPENDIX A

DETAILED DESCRIPTION OF METHODOLOGY FOR CALCULATING EMISSION INVENTORIES

Emission inventories were calculated using the Mobile I computer program. The Mobile I routine is based upon vehicle-specific emission factors for vehicles operating through the EPA's Federal Test Procedure (FTP) urban driving cycle. The program, thus, contains tables of emission levels for each model year vehicle from 1950 to 1990 for various vehicle ages between 0 and 20 years old. Separate tables are used for light-duty vehicle (LDV), light-duty truck 1 (under 6,000 lb gross) LDT-1, light-duty truck 2 (between 6,000 lb and 8,500 lb gross) LDT-2, heavy duty diesel, and heavy duty gasoline. Separate tables are also given for three geographic regions: California, high altitude areas, and the rest of the country. The latter tables are used for Wisconsin.

Since the basic emission factors are FTP specific, factors must be adjusted to reflect driving patterns in local areas. Mobile I contains correction factors for temperature, speed, hot/cold/stabilized travel, air conditioning, vehicle load, trailer towing, and humidity. Due to lack of reliable data for Wisconsin, default values (FTP-specific conditions) are used for air conditioning, vehicle load, and trailer towing. Humidity affects nitrogen oxide only and, thus, is irrelevant for our applications. Hot/cold/stabilized VMT is assumed to be the same as national averages: 21 percent/27 percent/52 percent. Temperature is taken at 75°F - this represents a typical July day when vehicle emissions are most acute.

The most important correction factor is vehicle speed. Emissions are not linear with respect to speed. So, whenever possible, speed classes must be differentiated. For all counties except Brown and Dane, speed classes are created by dividing travel between freeways, arterials, and local roads.

For a particular year, say 1987, the above factors give emissions per mile traveled for vehicles of various ages. To get aggregate per mile emissions for 1987, the emission factors for the various aged vehicles are weighted by the travel proportion for vehicles of that age (e.g., see the last column of Table 105). The data used in calculating travel proportions, the distribution of vehicle ages and the travel of vehicles by age, are national averages contained in Mobile I. A Wisconsin vehicle age distribution for a particular year is inappropriate since it would reflect low sales in periods of recession and these cyclic fluctuations would be projected into the future periods.

To get aggregate emissions per mile for a particular county or region (Table 9 and Table 10), values must be combined across the various speed classes (freeways, arterials, local roads). This is achieved by taking

Table 105. TRAVEL WEIGHTING FACTOR CALCULATION LIGHT-DUTY VEHICLES

Vehicle age	(a) Fraction total registration	(b) Annual mileage accumulation rate	(a)*(b)	((a)*(b)/sum) Travel fraction
1	0.075	15,900	1,192.5	0.106
2	0.107	15,000	1,605.0	0.142
3	0.107	14,000	1,498.0	0.133
4	0.106	13,100	1,388.6	0.123
5	0.100	12,200	1,220.0	0.108
6	0.092	11,300	1,039.6	0.092
7	0.085	10,300	875.5	0.077
8	0.077	9,400	723.8	0.064
9	0.066	8,500	561.0	0.050
10	0.052	7,600	395.2	0.035
11	0.039	6,700	261.3	0.023
12	0.027	6,600	178.2	0.016
13	0.018	6,200	111.6	0.010
14	0.014	5,900	82.6	0.007
15	0.009	5,500	49.5	0.004
16	0.006	5,100	30.6	0.003
17	0.005	5,000	25.0	0.002
18	0.005	4,700	23.5	0.002
19	0.005	4,400	22.0	0.002
20	0.004	4,400	17.6	0.002
		Sum:	11,301.0	

weighted averages using vehicle miles traveled (VMT) for the weighting fractions. To calculate total daily emission levels (Table 11 and Table 12), emissions per mile are multiplied by VMT. The raw VMT and speed data used in this study are given in Table 106 and Table 107. These data are interpolated to the analysis years of 1977 and 1987 and are given in Table 108 and Table 109.

To calculate the effect of an I/M program on emissions, EPA derived - Appendix N, credits (percent reductions) are applied to emission factors. I/M credits are given for carbon monoxide and hydrocarbons, various technologies of vehicles (technology 1 vehicles built prior to 1975, technology 2 vehicles built from 1975 to 1979, technology 3 vehicles built in 1980 and technology 4 vehicles built after 1980) with and without mandatory maintenance, with stringency levels of 10, 20, 30, 40 and 50 percent, and for the number of years I/M has been in effect. In this study, I/M included mandatory maintenance, was at a stringency level of 30 percent, and had been in effect for 5 years (from 1982 to 1987). These I/M credits are also specific to vehicle type. These credits differ substantially from those found in the May 1977 version of Appendix N. Current I/M credits are not yet available for other vehicle types, thus I/M is assumed to apply only to light duty vehicles.

TABLE 106. DAILY VMT FOR BROWN AND DANE COUNTIES

Brown County - VMT analysis is for an area which is 85.4 percent of the county population. VMT is approximately 10 percent low since some local streets are omitted.

1974	1,441,506
2000	3,081,910

Average speeds are:

1974	31.6 mph
2000	23.0 mph

Vehicle types are

Auto	85.0%
Light truck	10.3%
Heavy truck (gas)	3.2%
Heavy truck (diesel)	1.5%

Dane County - VMT analysis is for an area which is 72.8 percent of the county population. VMT is approximately 10 percent low since some local streets are omitted.

1970	2,725,797
2000	4,278,454

Average speeds are:

1970	32.4 mph
2000	30.9 mph

Vehicle types are

Auto	85.0%
Light trucks	8.5%
Heavy trucks (gas)	4.0%
Heavy trucks (diesel)	2.5%

Source: Wisconsin Department of Transportation
Madison, Wisconsin.

TABLE 107. DAILY VMT AND AVERAGE SPEED

	1972					1985					2000				
	LDV	LDT	HDG	HDD	Average speed (mph)	LDV	LDT	HDG	HDD	Average speed (mph)	LDV	LDT	HDG	HDD	Average speed (mph)
Kenosha Co.															
Freeways	304,200	4,900	4,000	68,600	65.0	368,000	22,000	3,200	68,00	53.9	732,400	41,300	9,400	97,400	53.4
Arterials	895,300	72,000	53,400	25,300	32.6	1,423,800	128,500	53,100	26,300	35.1	1,706,200	102,000	109,100	30,600	36.1
Milwaukee Co.															
Freeways	3,404,300	201,900	238,300	132,500	48.5	4,441,200	270,500	267,800	154,900	41.2	5,073,200	328,600	296,000	196,200	47.0
Arterials	6,078,700	308,100	321,400	9,800	24.5	5,525,200	374,100	329,600	23,000	25.1	5,704,200	375,800	375,300	21,400	24.0
Ozaukee Co.															
Freeways	182,000	11,300	7,600	22,100	62.9	444,500	34,200	9,100	62,000	54.2	549,300	34,500	19,300	78,700	54.3
Arterials	521,500	34,100	32,400	39,000	38.6	612,700	40,700	32,600	4,200	36.3	749,400	39,000	43,700	5,000	36.4
Racine Co.															
Freeways	324,100	11,600	15,600	63,700	64.5	550,700	27,300	13,900	69,900	54.2	1,022,400	43,600	20,000	91,200	53.6
Arterials	1,204,200	110,200	75,500	8,100	29.6	1,568,100	141,500	76,800	11,900	33.2	1,654,300	92,300	142,500	14,300	34.0
Walworth Co.															
Freeways	147,700	8,900	4,600	4,000	64.6	322,500	32,900	12,300	36,000	53.6	964,200	100,400	22,100	149,800	52.8
Arterials	621,200	76,300	68,300	51,200	39.7	826,800	105,700	61,500	41,500	40.6	992,000	100,600	82,400	39,200	41.5
Washington Co.															
Freeways	166,800	9,600	5,700	7,900	65.0	351,600	39,800	7,900	43,200	53.2	691,100	52,200	37,300	71,700	53.0
Arterials	786,200	82,300	56,200	36,300	43.3	826,700	118,500	58,200	22,800	38.2	948,700	71,700	104,300	22,500	38.2
Waukesha Co.															
Freeways	814,000	47,900	56,100	51,100	60.8	1,474,200	117,600	72,500	66,300	53.1	1,591,800	118,500	99,100	76,100	54.6
Arterials	1,926,700	179,900	199,500	37,900	36.2	2,558,100	275,900	211,600	31,300	35.9	3,362,600	281,400	321,200	31,600	35.9
7 Counties															
Local/ Collectors	2,017,700	151,800	148,700	135,700	20.0	2,092,800	157,200	122,900	9,900	20.0	2,381,300	179,400	136,600	10,200	20.0

Source: SEWRPC, Milwaukee, WI

TABLE 108. WISCONSIN VMT 1977

	Σ VMT (000)	% LDV	% LDT 1	% LDT 2	% HDG	% HDD	Average speed (mph)
Kenosha Co.							
Freeway	412.4	79.7	1.7	1.1	0.9	16.6	60.7
Arterial	1,271.3	86.4	4.4	3.0	4.2	2.0	33.6
Milwaukee Co.							
Freeway	4,422.1	86.0	3.1	2.1	5.6	3.2	45.7
Arterial	6,538.8	89.7	3.1	2.0	5.0	0.2	24.7
Ozaukee Co.							
Freeway	348.7	81.2	3.5	2.3	2.4	10.7	59.5
Arterial	651.3	85.5	3.4	2.2	5.0	3.9	37.7
Racine Co.							
Freeway	509.9	80.7	2.1	1.4	2.9	13.0	60.5
Arterial	1,552.0	86.6	4.7	3.2	4.9	0.6	31.0
Walworth Co.							
Freeway	189.7	77.9	5.7	3.8	4.0	8.6	60.3
Arterial	901.1	77.7	5.8	3.9	7.3	5.3	40.0
Washington Co.							
Freeway	287.0	82.9	4.4	3.0	2.3	7.5	60.4
Arterial	986.1	81.3	5.9	3.9	5.8	3.2	41.3
Waukesha Co.							
Freeway	1,262.6	84.6	3.5	2.4	4.9	4.5	57.8
Arterial	2,626.0	82.6	5.0	3.3	7.8	1.3	36.1
7 County Local	2,426.5	84.3	3.8	2.5	5.7	3.6	20.0

All data is derived directly from Table 107 by linear interpolation.

Light-duty trucks are divided into LDT 1 and LDT 2 in proportions of 0.6 and 0.4.

TABLE 109. WISCONSIN VMT 1987

	Σ VMT (000)	% LDV	% LDT 1	% LDT 2	% HDG	% HDD	Average speed (mph)
Kenosha Co.							
Freeway	521	79.8	2.9	1.9	0.7	14.8	53.9
Arterial	1,674	87.2	4.7	3.2	3.3	1.6	35.1
Milwaukee Co.							
Freeway	5,232	86.5	3.2	2.1	5.2	3.0	41.2
Arterial	6,277	88.4	3.6	2.4	5.3	0.4	25.1
Ozaukee Co.							
Freeway	567	80.8	3.7	2.5	1.7	11.3	54.2
Arterial	711	88.8	3.5	2.4	4.7	0.6	36.3
Racine Co.							
Freeway	737	83.2	2.5	1.6	2.1	10.6	54.2
Arterial	1,811	87.2	4.7	3.2	4.3	0.7	33.2
Walworth Co.							
Freeway	464	79.9	4.9	3.2	3.0	8.9	53.6
Arterial	1,063	79.8	6.1	4.1	5.9	4.0	40.6
Washington Co.							
Freeway	499	79.5	5.4	3.6	1.8	9.8	53.2
Arterial	1,047	80.6	6.9	4.6	5.7	2.2	38.2
Waukesha Co.							
Freeway	1,750	85.2	4.1	2.7	4.2	3.8	53.1
Arterial	3,706	83.1	5.4	3.6	6.9	1.0	35.9
7 County							
Local	2,382.8	87.8	4.0	2.6	5.2	0.4	20
Brown Co.							
All	2,912.6	85.0	8.7	1.6	3.2	1.5	27.3
Dane Co.							
All	5,451.1	85.0	6.8	1.7	4.0	2.5	31.6

All data is derived directly from Tables 107 and 108 by linear interpolation

Light duty trucks are divided into LDT 1 and LDT 2 in proportions of 0.6 and 0.4.

For Brown $\text{VMT} = (1.1)\dfrac{\text{Table (G) Value}}{0.854}$ For Dane $\text{VMT} = (1.1)\dfrac{\text{Table (G) Value}}{0.728}$

REFERENCES

1. U.S. Environmental Protection Agency. Mobile Source Emission Factors. For Low-altitude areas. Final Document. EPA-400/9-78-006. March 1978.

2. U.S. Environmental Protection Agency. Appendix N - Emission Reduction Achievable Through Inspection and Maintenance of Light-Duty Vehicles, Motorcycles and Light- and Heavy-duty trucks. Proposed Rule. Federal Register 24(84):22177-22183. May 2, 1977.

APPENDIX B

ESTIMATED FUEL SAVINGS FOR 1987 DUE TO I/M

Fuel savings dut to I/M implementation in selected counties is calculated by determining the average fleet mileage for all vehicles less than 13 years old in 1987. Total vehicle miles traveled (VMT) per day is divided by this figure to yield a daily fuel consumption figure in gallons. Actual daily fuel conservation figures are calculated using this figure and various stringency rates and levels of fuel economy.

The formula used to calculate fuel savings:

$$\text{gallons saved per year} = \frac{(\text{VMT})(0.862)}{(\text{FM})} * S * F * 322$$

where: VMT = daily vehicle miles traveled by LDVs in 1987 in the nine counties I/M will cover

0.862 = portion of VMT generated by vehicles covered by I/M (see Tables 110, 111)

FM = average fleet mileage of LDVs covered by I/M in 1987 (see Table 111)

S = stringency rate

F = improvement in fuel economy realized by failed vehicles undergoing required maintenance

322 = factor to adjust daily VMT to yearly VMT

The total projected daily VMT by LDVs in the nine county area is 36,305,655. Only a portion of these VMTs are generated by LDVs covered by I/M. Since vehicles over 13 years old will be exempt from the program, their VMTs must be removed from this figure. This is accomplished using data in the EPA Mobile I computer routine that estimates vehicle registration fractions by model year along with average annual mileage accumulation rates by model year (Table 110). Summing these travel fractions determines that 86.2 percent of LDV VMTs will be generated by vehicles covered by an I/M program (Table 111).

An estimate of the 1987 average fleet mileage (FM) figure for vehicles covered by the program can be made using these travel fractions and estimated

TABLE 110. TRAVEL WEIGHTING FACTOR CALCULATION FOR LIGHT-DUTY VEHICLES

Year	Vehicle age	(a) Fraction total registration	(b) Annual mileage accumulation rate	(a) * (b)	[(a) * (b)/sum] travel fraction
1987	1	0.075	15,900	1192.5	0.106
1986	2	0.107	15,000	1605.0	0.142
1985	3	0.107	14,000	1498.0	0.133
1984	4	0.106	13,100	1388.6	0.123
1983	5	0.100	12,200	1220.0	0.108
1982	6	0.092	11,300	1039.6	0.092
1981	7	0.085	10,300	875.5	0.077
1980	8	0.077	9,400	723.8	0.064
1979	9	0.066	8,500	561.0	0.050
1978	10	0.052	7,600	395.2	0.035
1977	11	0.039	6,700	261.3	0.023
1976	12	0.027	6,600	178.2	0.015
Pre-1976	13+	0.066	5,491	362.4	0.032

Sum: 11,301.0

FROM: Mobile I, EPA; January 1978.

TABLE 111. EPA MPG SPECIFICATIONS AND AVERAGE FLEET MILEAGE FOR LDVs COVERED BY I/M IN 1987

Year	EPA mileage standard	Travel fraction[*]	$\frac{\text{Column (1) x column (3)}}{0.968}$
1986	27.5	0.142	4.530
1985	27.5	0.133	4.243
1984	27	0.123	3.853
1983	26	0.108	3.258
1982	24	0.092	2.562
1981	22	0.077	1.965
1980	20	0.064	1.485
1979	19	0.050	1.102
1978	18	0.035	0.731
1977	17.5	0.023	0.467
1976	16.8	0.015	0.292
Total		0.862[†]	24,488

[*] From Table 110

[†] Note: This column totals less than 1 indicating that part of the vehicle population is 12 or more years old.

SOURCE: Federal Register, Book 1, Vol. 42, No. 126, p. 33534, Thursday, June 30, 1977 and Table 110.

fuel economy standards that have been set by EPA by model year. This calculation results in an average figure of 24.488 miles per gallon in 1987 (Table 111).

Table 112 presents estimated savings in gallons in 1987 varying the stringency rate between 10 and 50 percent and varying the increase in fuel economy realized by vehicles that failed between 2 and 10 percent.

TABLE 112. POTENTIAL ANNUAL FUEL SAVINGS FROM I/M FOR SELECTED COUNTIES IN 1987 (000 GALLONS)

Increase in fuel economy (%)	Stringency level (%)								
	10	15	20	25	30	35	40	45	50
2	823	1,234	1,646	2,058	2,469	2,880	3,292	3,704	4,115
3	1,234	1,852	2,469	3,086	3,704	4,321	4,938	5,555	6,173
4	1,646	2,469	3,292	4,115	4,938	5,761	6,584	7,407	8,230
5	2,058	3,086	4,115	5,144	6,173	7,202	8,230	9,259	10,288
6	2,469	3,704	4,938	6,173	7,407	8,642	9,876	11,110	12,346
7	2,880	4,321	5,761	7,201	8,642	10,082	11,522	12,963	14,403
8	3,292	4,938	6,584	8,230	9,876	11,522	31,168	14,815	16,461
9	3,704	5,555	7,407	9,259	1,111	12,963	14,815	16,666	18,518
10	4,115	6,173	8,230	10,288	12,346	14,403	16,461	18,518	20,576

APPENDIX C

DETAILED DESCRIPTION OF COSTS AND FEE CALCULATIONS

This appendix contains a detailed description of the methodology used in calculating annual costs and fees. First, capital and start-up cost are converted to annual figures in real dollars. These figures are then added to annual operating and administrative costs, so as to arrive at the yearly cost of the whole project. A uniform real dollar fee is then calculated, along with a second fee that is uniform in actual dollars.

INITIAL CAPITAL COSTS

The capital investment in equipment is assumed to yield equal benefits for each of 5 years and be fully depreciated thereafter. The interest rate is the marginal return on capital in the absence of inflation.

In annualizing equipment costs, the following formulas are employed. The net present value of an investment (NPV) that yields 1 dollar of service for each of n years at a capital growth rate of i is:

$$NPV = \sum_{k=1}^{n} \frac{1}{(1+i)^{k}} = 1 - \left[(1+i)^{-n}\right] \Big/_{i} \qquad (1)$$

Thus, an investment of 1 dollar yields annual benefits: $\frac{1}{NPV} = \frac{i}{1-(1+i)^{-n}}$ for each of n years. Thus $\frac{1}{NPV}$ represents amortized costs in constant dollars. In the case of $n = 5$ and $i = 0.03$, $NPV = 4.580$ and $\frac{1}{NPV} = 0.2184$, and in the case of $n = 5$ and $i = 0.06$, $NPV = 4.212$ and $\frac{1}{NPV} = 0.2374$.

For buildings and structures, investment is assumed to yield a constant flow of capital services for 20 years and be fully depreciated thereafter. The above formulas are employed with $n = 20$. This yields $NPV = 14.877$ and and $\frac{1}{NPV} = 0.067$ when $i = 0.03$; and $NPV = 11.469$ and $\frac{1}{NPV} = 0.087$ when $i = 0.06$. If structures are liquidated before 20 years, their sale price is assumed to be the capitalized flow of the remaining capital services (i.e., if sold after j years, the sale price will be:

$$\sum_{k=1}^{20-j} \left(\frac{1}{NPV(1+i)}\right)^{k}$$

for each dollar of initial investment). This assumption enables use of the above amortization factor, $\frac{1}{NPV}$, without making further adjustments.

Land is assumed to yield a constant level of services in perpetuity ($n = \infty$ in the above formulas). So a dollar investment yields $\frac{1}{NPV} = i$ dollars of service each year. Again, we assume the resale price of investment (in this case, land) is the capitalized flow of the remaining services. This implies that the value of land is unchanged from year to year, and the annual benefit (cost of capital service) is (land value) (i), regardless of when land liquidation occurs.

One-Time Start-Up Costs

One-time start-up costs, like capital costs, occur at the beginning of the project. However, these expenditures do not yield a flow of services or have a resale value, as do capital investments. Even still, start-up expenditures can be recouped over a period of time. We assume a 5-year period of repayment with equal yearly payments in constant dollars. Therefore, the annual cost of each dollar of start-up cost is: $\frac{1}{NPV} = \frac{i}{1-(1+i)^{-5}}$, which equals 0.2184 when $i=0.03$ and 0.2374 when $i=0.06$.

Annual Operating and Administrative Costs

These costs are presented as annual figures. To obtain total annual cost in constant dollars, the annual operating and administrative costs are added directly to the annual capital and start-up costs.

Fee Calculations

A fee, f_c, reflecting constant dollars, is calculated by dividing total annual costs by the number of paid inspections per year. This fee is designed to recoup all of the costs included in Table 3-1.

Interest Rates and Constant Dollars

All of the proceeding calculations are performed in constant 1978 dollars. To get figures in actual dollars for years other than 1978, all annual costs, amortized costs, and fees must be increased by the amount of inflation since 1978.

Interest rates used with constant dollars are those reflecting the real return on capital. Actual interest rates include compensation to offset the diminished buying power of money under inflation, and thus, are inappropriate here. In this study, we employ two real rates of return for capital, 3 percent and 6 percent. These rates are lower and upper bounds; the exact rate depends upon the source of financing (i.e., debt, equity, or taxpayers' foregone investment.)

Inflation

The above-mentioned fee is in real (constant) dollars and must be adjusted for inflation. These adjustments will cover increased operating costs as well as the difference between the market rate of interest and the real rate of return on capital.

A second fee, f_a, will also be calculated. This fee will be uniform in actual dollars over time. In calculating this fee, an inflation rate ρ must be assumed.* In this report, it will be assumed that $\rho = 0.07$. For notational convenience, let r = market rate of interest and i = real return on capital ($r = i+\rho$). Then, for investments (capital costs and start-up costs) an assumption of uniform capital services in actual dollars allows the use of the previous formulae for $\frac{1}{NPV}$ with r substituted for i.† The factors for amortization are shown in Table 113 below:

TABLE 113. FEE, f_a, AMORTIZATION FACTORS

Cost category	$\frac{1}{NPV}$	i=0.03	i=0.06
Land	r	0.10	0.13
Buildings and structures	$\frac{r}{1-(1+r)^{-20}}$	0.117	0.143
Equipment and start-up costs	$\frac{r}{1-(1+r)^{-5}}$	0.264	0.284

Annual operating and administrativd costs must be transformed from constant to actual dollars. Actual annual cost, is equal to the product of (1) constant annual cost and (2) a transformation factor, T; this transformation factor is determined from:

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*It shall be noted that the first fee, f_c, was independent of ρ.

†Capital investments no longer yield uniform services, but now yield accelerated depreciation.

$$T = \frac{1}{\sum_{k=1}^{n} \left(\frac{1}{1+r} \right)^k} \sum_{k=1}^{n} \left(\frac{1+\rho}{1+r} \right)^k = \frac{r}{1-(1+r)^{-n}} \sum_{k=1}^{n} \left(\frac{1}{1+ \quad \frac{1+r}{1+\rho} - 1} \right)^k$$

$$= \frac{r(1+\rho)}{i} \left(\frac{1-(1+i/1+\rho)^{-n}}{1-(1+r)^{-n}} \right)$$

where n = number of years = 5. Therefore, when $i = 0.03$ then $T = 1.215$, and when $i = 0.0t$ then $T = 1.210$.

The fee, f_a, is calculated in a manner similar to the original fee, f_c. Annualized costs are summed and divided by the annual number of paid inspections to arrive at f_a.

APPENDIX D

SENSITIVITY OF BREAKEVEN FEES

The breakeven fees are dominated by the annual operating costs in all of the centralized approaches. The annual operating costs are highly dependent primarily on two factors: the throughput rate, and the personnel wages. The breakeven fees, therefore, will change considerably by varying these two elements. As an example, loaded mode emission testing at a 3-minute throughput rate could be experienced. The effective changes result in a 29 percent increase in both the breakeven fee in constant dollars (f_c) and the breakeven fee in actual (inflated) dollars (f_a). The calculations showing effective changes are shown in Table 114.

TABLE 114. INCREASE IN COSTS FOR LOADED MODE EMISSIONS TESTING WITH A 1-MINUTE INCREASE IN THROUGHPUT ($i=0.03$)

	3-Min throughput	2-Min throughput	Increase
Land costs	$1,940,271	$1,312,509	32%
Building costs	5,294,000	3,487,875	34%
Equipment costs	4,948,000	3,385,000	32%
Test personnel	3,755,500	2,536,125	32%
Adm. personnel	504,250	504,250	0%
Calibration vans	98,000	70,000	29%
Central computer	250,000	250,000	0%
Equipment calibration	61,600	44,000	29%
Equipment maintenance	989,600	677,100	32%
Property tax	301,984	189,293	37%
Real estate tax	50,411	31,812	37%
Utilities	189,250	131,438	31%
Insurance	108,000	70,500	35%
Public relations	180,000	180,000	0%
Annual inspector training	528	336	36%
Start-up costs	2,874,439	2,169,072	25%
f_c (fee in constant dollars)	4.23	3.28	29%
f_a (fee in actual dollars)	5.28	4.09	29%

By changing the personnel wages to reflect a 25 percent increase (perhaps due to unionization or a civil service raise, assumed over a time span of 3 years) the reflected change in f_c (fee in constant dollars) would be 10 to 11 percent higher. The change in f_a (fee in actual dollars) would be a 10 to 11 percent increase. The current and increased breakeven fees are shown in Table 115.

TABLE 115. INCREASE IN BREAKEVEN FEES WITH A 25 PERCENT INCREASE IN PERSONNEL WAGES (i=0.03 percent)

Option		Current wages	25% Higher wages	Increase
1	fc	7.425	8.195	10%
	fa	9.341	10.273	10%
2	fc	4.845	5.377	11%
	fa	6.055	6.700	11%
3	fc	3.251	3.608	11%
	fa	4.052	4.486	11%
4	fc	7.490	8.257	10%
	fa	9.416	10.348	10%
5	fc	3.324	3.648	10%
	fa	4.129	4.562	10%

A policy of providing a free retest to owners of failed vehicles as a consumer protection measure results in an increase in the breakeven fee equal to the stringency factor, since the total annualized cost of the program would be split by that many fewer tests. In this example, a 30 percent stringency factor, the cost for an inspection would be 30 percent higher in a program allowing for a free retest than in one requiring a paid retest. The breakeven fees for both alternatives are provided in Table 116.

TABLE 116. INCREASE IN f_c (BREAKEVEN FEE IN CONSTANT 1978 DOLLARS) WITH A FREE RETEST POLICY (i=0.03)

Option	f_c with paid retest	f_c with free retest
I	$6.95	$9.03
II	3.28	4.26
III	3.06	3.97
IV	6.57	8.54
V	3.02	3.93

APPENDIX E

GLOSSARY

accuracy: The degree by which an instrument is able to determine the true concentration of a pollutant in the exhaust gas sampled.

actual dollars: The face value of money in any particular year. With inflation, the buying power of actual dollars decreases.

air contaminants: Any fumes, smoke, particulate matter, vapor gas, or any combination, but excluding water vapor or stream condensate.

air-fuel ratio: The expression of the proportional mixture of air and gasoline created by the carburetor. Usually expressed as a numerical relationship such as 14:1, 13:1, etc.

ambient air: The surrounding or outside air.

amortization factor: The annual cost of 1 dollar of capital expenditure. Amortization factors are applied to capital costs to determine annual costs.

calibration gases: A blend of HC and CO gases using nitrogen as a carrier gas.

carbon monoxide: A nonirritating, colorless, odorless gas at standard conditions which has the molecular form of CO.

catalytic emission control system: Device to reduce automobile emissions by converting CO and HC emissions to harmless carbon dioxide and water.

certificate of compliance: A document which is issued upon completion of the inspection which records the results of the inspection and serves as proof of said inspection for vehicle owner.

certified mechanic: An individual licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.

certified station: A private facility licensed to install, repair and adjust motor vehicle engine emissions related components and pollution control devices in order that the motor vehicle meet applicable emissions standards.

chassis dynamometer: A machine equipped with two parallel rollers which support the rear wheels of a motor vehicle. When positioned on the dynamometer the vehicle may be "driven" to simulate the loadings the engine would experience when the vehicle is operated on the road. A power absorption unit is connected to the rollers to simulate the loading from the various sources of fluid and mechanical friction present during road operation. Weights can also be coupled to the rollers to simulate the inertial effects of vehicle mass during acceleration and decelleration.

crankcase emissions: The products of combustion emitted into the ambient air from portions of the engine crankcase ventilation or lubrication system.

degradation: The decreased effect of I/M on emission reduction due to normal wear of engine system.

deterioration: A synonym for degradation indicating an increase in emission levels due to wear.

drift: The amount of meter reading change over a period of time. Zero drift refers to change of zero reading. Span drift refers to a change in reading of a calibration point on the upper half of the scale. The calibration point is established by reading a calibration gas of known concentration.

emission inspection program: An inspection and maintenance program in which each vehicle is subjected at specified intervals to a test of its emissions under specified conditions. The emission levels are compared with a standard established for the vehicle class. If the emissions are higher than the standard, the vehicle is failed and must be adjusted or repaired to bring its emissions into compliance with the standards.

exhaust gas analyzer: An instrument for sensing the amount of air contaminants in the exhaust emissions of a motor vehicle.

exhaust emissions: The products of combustion emitted into the ambient air from any opening downstream of the exhaust ports of a motor vehicle engine.

fleet owner authorized stations: A permit issued to a qualified fleet owner to perform vehicle emissions inspection limited to his fleet only.

fleet operator: The owner of a fleet of a designated number of vehicles.

hang-up: HC which clings to the surface of the sampling and analyzer system in contact with the gas sample stream which causes an erroneous indication of HC in the measured value.

heavy-duty vehicle: Any motor vehicle designed for highway use which has a gross vehicle weight of more than 8,500 pounds.

hydrocarbons: A compound whose molecular composition consists of atoms of hydrogen and carbon only.

idle test: An emission inspection program which measures the exhaust emissions from a motor vehicle operating at idle. (No motion of the rear wheels.) A vehicle with an automatic transmission may be in drive gear with brakes applied or in neutral gear.

independent contractor: Any person, business firm, partnership or corporation with whom the state may enter into an agreement providing for the construction, equipment, maintenance, personnel, management and operation of official inspection stations.

inspection and maintenance program: A program to reduce emissions from in-use vehicles through identifying vehicles that need emissions control related maintenance and requiring that maintenance be performed.

inspection station: A centralized facility for inspecting motor vehicles and pollution control devices for compliance with applicable regulations.

inspector: An individual who inspects motor vehicles and pollution control devices for compliance with applicable regulations.

instrument: The system which samples and determines the concentration of the pollutant gas.

key mode test: A loaded mode test in which exhaust emissions are measured at high and low cruise speeds and at idle. The cruise speeds and dynamometer power absoprtion settings vary with the weight class of the vehicle. The dynamometer loading in the high cruise range is higher than normal load in order to more efficiently expose malfunctions leading to high emissions.

light-duty vehicle: A motor vehicle designed for highway use of less than 8,501 pounds gross vehicle weight. Further distinctions are sometimes made between light-duty automobiles and light-duty trucks such as pickup trucks.

loaded mode test: An emission inspection program which measures the exhaust emissions from a motor vehicle operating under simulated road load on a chassis dynamometer.

manufacturer's specifications: The specifications or settings established by the manufacturer for proper operation. These settings must be followed in order to maintain proper emission controls and vehicle performance.

market rate of interest: An interest rate that includes the real return on capital, a risk premium, and compensation for inflation.

model year of vehicle: The production period of new vehicle or new vehicle engines designated by the calendar year in which such period ends.

motorcycle: A motor vehicle having a seat or saddle for use of the rider and designed to travel on not more than three wheels in contact with the ground, but excluding a tractor.

motor vehicle: Any self-propelled vehicle which is designed primarily for travel on public right of ways and which is used to transport persons and property.

net present value (NPV): The present value of future benefits and cost. When actual dollars are used, benefit and costs are discounted by the market rate of interest. When real dollars are used, benefits and costs are discounted by the real return on capital.

nonattainment area: An area designated by the EPA which does not meet National Ambient Air Quality Standards for a specific pollutant.

photochemical oxidants: Those pollutants resulting from the chemical combination of reactive hydrocarbons with nitrogen oxides in the presence of sunlight. These produce ozone and other complex chemical compounds, which are dangerous to human health.

positive crankcase ventilation: A system designed to return blowby gases from the crankcase of the engine to the intake manifold so that the gases are burned in the engine. Blowby gas is unburned fuel/air mixture which leaks past the piston rings into the crankcase during the compression and ignition cycles of the engine. Without positive crankcase ventilation these gases, which are rich in hydrocarbons, escape to the atmosphere.

prescribed inspection procedure: Approved procedure for identifying vehicles that need emissions control related maintenance.

real dollars: (Sometimes called constant dollars.) Dollars that have the same buying power from year to year. To arrive at actual dollars, real dollars must be increased by the amount of inflation. For example: with an annual inflation of 7 percent, $100 in year x is equal to $107 actual dollars in year x + 1.

(real) rate of return on capital: The return on capital in the absence of inflation. This is equal to the marginal product of capital when combined with land and labor in production.

registered owner: An individual, firm, corporation or association whose name appears in the files of the motor vehicle registration division of the department of motor vehicles as the person to whom the vehicle is registered.

repeatability: The instrument's capability to provide the same value for successive measures of the same sample.

response time: The period of time required by an instrument to provide meangingful results after a step change in gas concentration level initiated at the tailpipe sample probe.

smoke: Small gasborne and airborne particles, exclusive of water vapor, arising from a process of combustion in sufficient number to be observable.

stringency factor: The percentage of total vehicles tested in an inspection/maintenance program in a given time period that fail inspection and are required to have maintenance performed.

tampering: The illegal alteration, modification, or disconnection of emission control devices or adjustments or manufacturer tuning specifications on motor vehicles for the purpose of controlling vehicle emissions.

vehicle dealer: An individual, firm, corporation or association who is licensed to sell motor vehicles.

vehicle emissions standard: A specific emission limit allowed for a class of vehicles. The standard is normally expressed in terms of maximum allowable concentrations of pollutants (e.g., parts per million). However, a standard could also be expressed in terms of mass emissions per unit of time or distance traveled (e.g., grams per mile).